JOURNAL

VOLUME 8 NUMBER 2 • FEBRUARY 1952

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National SPE Officers for 1952: President William O. Bracken, (left) and Vice-President Walter Oelman

PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.

with

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Newark Officers And Committees Are Now Selected

By Anthony Naturale

On January 9, 1952, the Newark Section held its annual joint meeting with the New York Section at the Military Park Hotel, Newark, N. J. More than 125 members and guests were present at this meeting.

Our 1951 President, Mr. Peter Simmons of Dow Chemical Co., opened the meeting with words of thanks to Directors, Committee Chairmen and Members of the organization for their splendid cooperation during the past year. He then introduced our 1952 President, Mr. Edward Rowan of Dillon & Beck Manufacturing Co., Hillside, N. J.

Mr. E. Rowan welcomed the New York SPE members and guests and then made several announcements and introduced the 1952 Committee Chairmen as follows:

Membership Committee
Jay D. Sherman of Reed Prentice Corp., New York.

Credentials Committee
Robert H. Hoehn of Mack Molding Co., Wayne, N. J.

Program Committee
William H. Willert (until June '52) of Harting Eng. & Mach. Co.
Donald W. Biklen (until June '53) of Orangeburg Mfg. Co., Orangeburg, N. Y.

House Committee
David H. Garrison of The Garrison Co., Plainfield, N. J.

Publicity Committee
Edward G. Avkerman of Riedl & Freede, Patterson, N. J.

Technical Societies Council Representative
Edward O. Koplitz of Bright Star Battery Co., Clifton, N. J.

SPE Reporter
Anthony Naturale (1951-1952) of Naturale Tools, Inc.
W. J. Trautweiler (1952-1953) of Newark Die Co., Newark, N. J., Newark, N. J.

Educational Committee
Peter W. Simmons of Dow Chemical Co.

Professional Activities Committee
Wayne M. Schrag of Gering Products, Kenilworth, N. J.

Mr. Edward Rowan also reviewed the financial report and showed the substantial gains that were made during the past 7 years.

The meeting was then turned over to our program chairman, Mr. William H. Willert who introduced Mr. John R. Charlton, Manager Plastics Division, Ciba Company, Inc., N. Y. Mr. Charlton's topic "The Uses and Characteristics of Epoxy Resins" was very well presented. Mr. Charlton demon-

(Continued on page 17)

JOURNAL

Vol. 8 February, 1952 No. 2

Published monthly except July and August by the

SOCIETY OF PLASTICS ENGINEERS, INC.
409 SECURITY BANK BLDG.
ATHENS, OHIO

Dr. Jesse H. Day, Editor

Editorial Advisory Board: MARIO PETRETTI, J. H. DUBOIS, WAYNE PRIBBLE, CARL J. FROSCH

30 cents a copy **$3.00 a year**

Entered as second-class matter at the Post Office at Athens, Ohio.

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The Society of Plastics Engineers Journal is not responsible for the views expressed by individual contributors. Copy for each issue should be received at 409 Security Bank Bldg., Athens, Ohio, before the fifth of each month.

The President's Corner

The Eighth Annual Technical Conference held in Chicago last month was eminently satisfactory in every respect. The excellent papers, capable speakers, and the vigorous and constructive exchange of ideas, both at the meetings and in the rooms (and in the National Council!) show a healthy condition of growth by our organization. Not enough credit can be given the National Conference Committee under the guidance of Jack Bent, General Chairman, for the efficient functioning and fine support of the meeting. These men have made a substantial contribution in terms of hours, effort and dollars. We're glad to give you the names of these men and are happy to extend to them the thanks of the Society for undertaking a tough job with such success.

John T. Bent	E. E. Eckenbeck, Jr.
R. K. Gossett	Ned Porte
R. J. Linehan	R. S. Stephens
Charles Schiff	Tom H. Cleavenger
Clarence McCormick	Stanley F. Peters
Maurice Meltzer	Ray Daniels

In all young organizations, such as ours, there are bound to be changes in the functions, duties and goals of its component units while the society as a whole holds to its original course. Accordingly, in the coming months we hope to have information for you on such subjects as Professional Activities, SPE Journal and other items of wide interest in the Society.

Now for a final point—If you have a gripe or inquiry about the National society, contact your National Councilman. He'll be a good sounding-board, bellowing your objections to all 24 sections; or he may be able to reconcile the differences you have to the mutual advantage of all concerned. Remember, if you're going to blow your top, be sure the steam generates some action for the general good.

W. O. Bracken

POSITIONS OPEN

PROJECT ENGINEER, preferably M.E. to handle product development of all thermoplastics with progressive New England Company. Experience in thermoplastics desirable but not essential. Send complete resume giving education, experience and salary commanded or required in first letter to Box 522, SPE Journal, 409 Security Bank Bldg., Athens, Ohio.

WANTED: Plastics engineer, not over 35. Technical graduate preferred. About ten years' experience in development and production. Excellent opportunity for advancement in well established organization. Products in industrial rather than novelty field. In replying give full resume of training and experience. Box 52-3 SPE Journal, 409 Security Bank Bldg., Athens, Ohio.

9th SPE TECHNICAL CONFERENCE
JANUARY 21—23, 1953
Statler Hotel Boston, Mass.

A Committee Report—

Educational Activities Varied

James M. Church, *Chairman*
Columbia University

During the past year your Education Committee has been actively pursuing the program which was presented to the Council at their meeting of last January and heartily endorsed by an official action of the Council at that time. We are happy to report that considerable progress has been made since then in the accomplishment of many of the objectives of this program, which will be noted in a review of these as given in this report.

1. Organization of Educational Forum

In an effort to inform the membership of the Society and obtain their endorsement of the S.P.E. Education Program as conceived and adopted in 1950, our Committee has been attempting to interest local sections in holding a forum type meeting on the general theme of "The Training of the Plastics Engineer." Thus far only one such forum meeting has been held, that of the Twin City Section in November, 1950, although several sections have denoted an interest in this type of meeting and have expressed a desire to hold a forum session as part of their meeting program. In order further to stimulate local section interest in a program of this type, such a forum meeting was scheduled as a special attraction of this year's national meeting in Chicago. Under the direction of Professor Louis F. Rahm of Princeton University, formerly Chairman of the S.P.E. Education Committee, who acted as Moderator for the session, a panel of four speakers, two representing industry and two the profession, discussed the general topic, "What Should a Plastics Engineer Know?" By the time this report is presented, the results of this panel discussion will be known, and it is hoped that it proved sufficiently stimulating so that many of the local sections will be encouraged to attempt a meeting of this kind as part of their program for the coming year.

2. Establishment of a Technical Symposium Committee

At the Council meeting a year ago, this Committee recommended the establishment of a permanent committee for the solicitation and presentation of papers of a fundamental research nature in the field of plastics and high polymers as a part of the national meetings of the Society. Such a collection of papers, presented as a Symposium each year, should appeal to the more highly technically trained men of the industry and serve to keep the professional members informed of recent progress in basic plastic developments, as a part of the educational policies of the Society. This type of program would be held concurrently with a less technical program in order to provide topics of interest to both types of membership within the Society.

The Education Committee was authorized by the Council to proceed with the selection of a subcommittee to be known as "The Technical Symposium Committee" and to help with the organization of the first Technical Symposium as a part of the program of the next annual meeting of the Society in January, 1953. The subcommittee is now being formed and is to be composed of six members, two of which will also be members of the Education Committee. Announcement of the membership of this committee and its plans for the next year is to be made shortly.

3. Survey of Plastics Curricula in Colleges and Universities

Under the guidance of Professor Charles C. Winding of Cornell University, a survey of the offerings in plastic technology and related courses by various colleges and universities is being made. A preliminary questionnaire was sent to a selected list of 37 institutions, directed to the Heads of the Departments of Chemical Engineering who might be expected to be in charge of such courses or at least well informed about them. Replies were received from 35 of the 37 institutions solicited, indicating that 29 offer some courses in plastics technology although most were of an elementary or introductory character. Only 13 of the institutions gave any laboratory instruction in plastics as a part of the curriculum.

It is planned to follow up this first questionnaire with another requesting more details of the various courses, facilities, and topics of research at the different institutions, available to engineers as an aid to their training for possible positions with the plastics industry. It is also hoped that this survey may stimulate more interest on the part of educational institutions to offer a fuller program in plastics technology approaching that of the Educational Program setting forth a plastics curriculum for engineering students.

4. Promotion of S.P.E. Educational Program

In addition to the appeal to local sections for an Educational type forum as mentioned previously, a series of articles to be written by members of this Committee are planned for the S.P.E. Journal and will appear in forthcoming issues under a special column to be devoted to educational topics. In this way we hope to arouse the interest of the members of our Society in the type of training one should seek for advancement in this profession.

Also a contact between our Committee and the local sections through the appointment of a local representative or education chairman will be sought to help promote the National Education Program at the local section level.

Under the conditions of the revised Constitution of the Society pertaining to the membership of the Education Committee (Article X) one-third of the Committee is appointed each year for a three year term with length of service limited to two terms, thus allowing for a rotation in the membership of the Committee. This year, the four members of the Committee whose terms expire are: Mr. H. W. Rose of American Viscose Corporation, Dr. Norman A. Skow of Synthane Corporation, Dr. Ralph T. Nazzaro of The Westfield River Paper Company, and Mr. Murray Olyphant, Jr., of Princeton University. In addition, Mr. R. G. Leonard, on leave of absence from U. S. Rubber Company while serving in the U. S. Navy, has asked to be relieved of his Committee appointment for the coming year. The assistance of these men in the work of this Committee, giving freely of their time and effort in the interest of the Society, is gratefully acknowledged. We are pleased to announce that both Dr. Skow and Mr. Olyphant have agreed to a reappointment for another term, and it is hoped that the other two members of the present Committee will also consent to reappointments. A replacement for Mr. Leonard is being sought as a new member of the Committee.

Report On The

EIGHTH SPE TECHNICAL CONFERENCE

Panel and forum discussions, a 70th century archeologist, prize papers and excellent speakers make diversified program.

The banquet at the 8th SPE Technical Conference served an enthusiastic group of over 500. General Maris spoke on military applications and research

Record sixty degree temperatures visited Chicago during the 8th Technical SPE Conference, which was attended by some 750 members and guests.

For the first time, meetings of the National Council preceded the reading of the technical papers, so that the national officers and Councilmen were more in evidence at this Conference than has previously been the case. Meeting Wednesday morning, the Council elected officers for 1952.

An unusual feature of this Conference was the number of panel and forum discussions, with audience participation. These discussions were tape recorded, and will appear in the SPE Journal practically verbatim in the course of the next few issues. "What Should Plastics Engineers Know?", attended by an overflow audience of more than 300, was led by Louis Rahm of Princeton, and considered the curriculum best suited to prepare a man to be a plastics engineer.

Other panels were "Reinforced Plastics," led by A. J. Wiltshire of Apex Electric; "SPE Professional Activities," led by Sherwood L. Young of C. F. Church; "Mold Design," led by Carl F. Massopust of General American Transportation; "New Applications and Design of Plastics," led by Jean O. Reinecke, of J. O. Reinecke and Associates; and "Military Applications," chairmanned by R. K. Gossett of Gossett and Hill.

The panel on "New Applications": Jack Davis, Eric Furholmen, Thomas Muckenfuss, Wynn Cope, Jean O. Reinecke, James Johnston.

Luncheon speaker G. F. D'Alelio, vice president and manager of the research department of Koppers, spoke on "Molecular Engineering in Plastics." This talk, which we hope to publish in the next issue of the Journal, pointed up the interesting fact that both plastics and the materials of living animal and vegetable tissues are high polymers, and that research cutting across both fields is already a reality, as in the development and use of polyvinylpyrrolidone as a substitute for blood plasma.

The SPE Banquet, with more than 500 present, featured Major-General Ward H. Maris, GSC, Deputy Assistant Chief of Staff, G-4, for Research and Development. Excerpts from his talk are printed elsewhere in this issue. Soft-spoken and friendly, informal in his delivery, General Maris was both pleasant and interesting. All who heard

Luncheon speaker G. F. D'Alelio, SPE's Executive-Secretary Bess Day, and John Groesbeck.

A view of the registration desk at the 8th Technical Conference

him agreed with the remark made by John Bent, "I'm glad he's on our side!"

Islyn Thomas, retiring president of SPE, made presentations at the Banquet to the winners of the prize paper contest of checks and engraved certificates; David J. Sloane of Cleveland, Lester Engineering, $200; William Kosobud of Chicago, Detroit Mold Engineering, $100. Austion Herbst of El Monte, California, Irvington Varnish and Insulator, was not present. Thomas also presented $50 and a certificate to Ed Roberts, General Electric, Erie, Pa., for first prize in the SPE lapel pin design contest.

Islyn Thomas then was presented with a black plastic gavel by William O. Bracken. The gavel was engraved "Islyn Thomas, President Society of Plastics Engineers, 1951."

REGISTRATION

Members were pleased with the new, rapid registration procedure, which obviated the formation of long lines and tiresome waiting. The stack of "application for membership" forms at the registration desk went down steadily, which was a good omen for the future.

PUBLICATION

All papers presented at the Conference are scheduled for publication in the SPE Journal in the near future.

A number of well-known writers and publishers were present: William Cleworth (Plastics World); Fred Stanley (Modern Plastics); Arthur M. Merrill (India Rubber World); Rodney N. Hader (Chemical and Engineering News); Miss Jean Mowat, writer for The New York Journal of Commerce; Jack B. Muir, Rogers Publishing Co.; Alex E. Javitz, Gage Publishing Co.; Frank Soltan, Fairchild Publications; Kenneth Ross, Reinhold Publishing Corp., just to name a few.

Visitors from foreign countries included Rudolph Gaeth, Badische Aniline & Soda Fabrik, Germany; Carl H. Jacobson, Hammarby Bakelit Ind. A.B., Sweden, and many members from our Toronto and Quebec Sections.

The success of a Conference depends on a great many factors; the personnel of the conference committee, the support of the industry through company registrations, the quality of the speakers, the attendance of the SPE members, and the whole-hearted cooperation of the hotel management. The Eighth SPE Conference was fortunate in all these respects, and full credit for a smoothly functioning, well worth-while Conference should be given to everyone concerned.

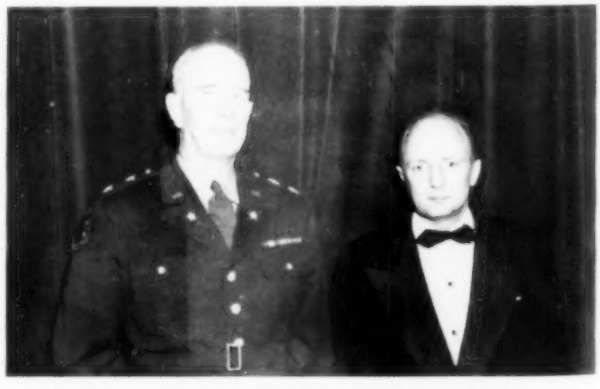
The Conference Committee was composed of: General Chairman, John T. Bent, Tennessee Eastman Corp.; Co-Chairman, R. K. Gossett, Gossett & Hill; Secretary, M. A. Self, Bee Chemical Co.; Finance, Budget and Treasurer, Charles Schiff, Breyer Molding Co.; Printing, R. J. Linehan, Continental Plastic Corp.; Reservation and Registration, Maurice Meltzer, Service Plastics, Inc.; Company Registration, Robert S. Stephens; Program, Stanley F. Peters, Monsanto Chemical Co.; Speakers, Tom H. Cleavenger, Koppers Co., Inc.; Ladies Entertainment, Carl Nagy, General Die Mould Mfg. Co.; House, Luncheon and Banquet, Ray Daniels, Dow Chemical Co.; Reception, J. C. Kazimier, Amos Molded Plastics, Inc.; Prize Papers, John W. French, Ger-Ell Manufacturing Co.; Sergeant-at-Arms, E. E. Eckenbeck, Jr., Midwest Plastic Products Co.; Favors and Door Prizes, Clarence McCormick, Superior Plastics; Publicity and Advertising, Ned H. Porte, General American Transportation Corporation.

Many thanks go to E. E. Eckenbeck, Jr., for the photographs of the Conference which appear in this issue of the Journal.

The Edgewater Beach Hotel is to be commended for its fine service, and especially Mr. Bauman of the hotel staff for his unfailing courtesy and constant prompt attention to our needs.

(Continued on Page 23)

Ed Roberts shows his prize winning SPE lapel pin design to Islyn Thomas



Banquet Speaker General Ward Maris and John Bent, conference committee chairman

SPE NATIONAL OFFICERS FOR 1952

William O. Bracken, President, is a member of the plastics technical service division of the Cellulose Products Department, Hercules Powder Co. He graduated from Tufts College, Bedford, Mass., with a B.S. degree in chemical engineering. Immediately after he joined the General Chemical Company plant in Buffalo. He worked for a short time at the Cambridge, Mass., plant of the BB Chemical Co. He joined the Hercules Powder Company in 1939 as a chemist at the Experiment Station in Wilmington, Delaware, as a member of the Hercules cellulose products plant at Parlin, N. J. He returned to Wilmington as a member of the Hercules cellulose plastics marketing section, and later served as an assistant product supervisor. He is a member of ACS and SPI.

Walter Oelman, Vice-president, was born and bred in Dayton. He left home long enough to attend the University of Illinois and the Harvard Business School. After nine years in the real estate management field, he entered the employ of the Standard Molding Corporation, where he is now Vice President and General Manager. Always active in community work, Mr. Oelman is a member of Dayton's Rotary Club and treasurer of the City of Oakwood Adam Schantz Sr. Corp., and vice president of the Reliable Fire Insurance Co.

John W. LaBelle, Secretary, is associated with Koppers Co., Inc., as Sales Manager New England District. He received his bachelor's degree in Chemical Engineering from Northeastern University in 1932. After being a chemist with Eastern Gas & Fuel Assoc. for five years he joined the Tar Products Division of Koppers Co. as Chief Chemist in materials and processes. In 1946 he was transferred to the Chemical Division and has been district sales manager in that division since April 1949. He has been active in the Society since becoming a member in 1948.

Don F. Hoffman, Treasurer, has long been active in the national affairs of SPE. He is one of the original members of the Society. Mr. Hoffman is Product Engineer and Plant Manager in complete charge of the Plastics Division of Evans-Winter-Hebb, Inc. He joined the company in 1943 as product engineer. Previously he has been a draftsman with Toledo Mold Co., and Owens-Illinois Glass Co. He was mechanical engineer with Owens-Illinois Glass Co. and chief engineer with Detroit Mold Engineering Corp.

William O. Bracken

Don F. Hoffman

He has received most of his education attending night school at St. Johns University, Toledo, University of Detroit, Toledo University and Michigan University Extension.

Other members of the National Council are:

Frank W. Reinhart, National Bureau of Standards, Baltimore-Washington; H. S. Nathan, Atlas Plastics, Inc., Buffalo; Richard J. Francis, consultant, Central Ohio; L. J. Swift, Jarrow Products, Inc., Chicago; G. E. Field, B. F. Goodrich Co., Cleveland; Lewis J. Pentland, Durez Plastics & Chemicals, Inc., Connecticut; Clark N. Robinson, Consultant, Golden Gate; Islyn Thomas, Newark Die Co., Newark; Stanley Bindman, Jamison Plastics Corp., New York; Wayne Pribble, Barrier-Pribble & Assoc., Northern Indiana; L. H. Barnett, Loma Plastics Inc., North Texas; N. R. Reyburn, Applied Plastics Div. of Keystone Brass Works, Northwestern Pennsylvania; R. G. Rea, Monsanto Canada Ltd., Quebec; Richard H. Bruce, Bakelite Co., Rhode Island and Southeastern Massachusetts; G. V. Delaire, Eastman Kodak Co., Rochester; Dan Otto, Plastic Parts & Sales, Saint Louis; Carl Eckenrod, Wright Mfg. Co., South Texas; Elbert Davis, New Plastics Co., Southern California; Robert Dunham, Owens-Illinois Glass Co., Toledo; Eric H. Huggins, Dow Chemical of Canada, Toronto; Jerome Formo, Minneapolis-Honeywell Regulator Co., Upper Midwest; Sherwood L. Young, C. F. Church Mfg. Co., Western New England.

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Plastical Archeology

By Dr. Johan Bjorksten
Bjorksten Research Laboratories
Madison, Wisconsin

Dr. Bjorksten, industrial archeologist, speaking before the 4998th SPE Technical Conference, discusses the early days of the Plastics Age. Thus with a humorous touch, the speaker makes some predictions as to the future of plastics—and succeeds in suggesting some remarkably cogent and profitable lines for progress.

Photographs prepared by Henry Dollard, Research Photographer, Bjorksten Research Laboratories.

Dr. Johan Bjorksten

This year, 6943, the Society has taken the somewhat unusual step of asking distinguished persons from distant scientific fields to speak on phases of their areas of study which bear upon the general subject of plastics and their uses. In the last few years, as most of you have heard from press reports, remarkable and significant discoveries bearing on the early history of the development of plastics have come to us from the field of industrial archeology. Foremost in this study have been Prof. Bookbrowser and his pupils, especially Dr. Johan Bjorksten, whose discoveries have given rise to many fruitful and thought-provoking theories. Both of these gentlemen are with us today and I have asked Dr. Bookbrowser of the Southern University of the Fifth Meridan, U. S. A. to say a few words and then to introduce Dr. Bjorksten. Dr. Bookbrowser.

The great population decentralization movement, which occurred at the peak of the Military Era, took place shortly after the dawn of the Atomic Age, about four thousand years ago, in the early years of the 21st century, A.D. The recent discoveries at Richmond of records sealed in lead under helium atmosphere tell us that the immediate cause of the movement was the practical impossibility of defending such excellent and obvious military targets as were the huge cities which then existed. By 1960 A.D. guided missiles were capable of soberingly accurate flights over distances of a thousand miles. Few persons then foresaw the great developments which were to take place in this weapon during the following seventy-five years, which resulted in accurate flight ranges of five thousand to ten thousand miles. The introduction of automatic corrections of the flight course by mechanisms in the missile, which guided it to the large city targets, made use of the higher temperatures and higher carbon dioxide content of the atmosphere over cities. Cities were therefore especially vulnerable on winter nights when the air was comparatively still.

Deep underground, in the Rockies, the Andes, the Himalayas and the Urals, the nations had huge installations for launching these missiles which could reach any spot on the globe carrying a formidable atomic explosive head. The cost of defending great cities, which formerly was considered by military men to be a mathematical function related to the cube of the population, now rose rapidly to an impossible value. The only defense was seen to be that of distributing the population, as evenly as possible, over the entire areas of countries. In this way it was hoped that the damage which could result from an average single missile would be too small to make international conquests attractive by the method of missile bombardment. This proved to be the case, as we know.

Inevitable

The enormousness of the task of decentralization prevented its being undertaken at once, though everyone realized it was ultimately to come. Finally, a real push was given to this lifesaving program by a Senator of that period who introduced into Congress a bill whereby 75% of the tax savings resulting from the decreased national defense costs, made possible by abandoning big cities, would be passed on to industries and individuals who voluntarily moved away from the great urban centers. Taxes had become so high because of costs of earlier practice wars that this opportunity was eagerly seized upon by many who saw the great advantage in being reimbursed for doing something which they realized was inevitable, in the nature of things, in the not distant future.

The rate of this decentralization movement was greatly increased by the unfortunate experience of Chicago. The story has now become a classic, like that of Mrs. O'Leary's cow and the Great Chicago Fire, but unfortunately there is little doubt about the truth of it. During an especially angry and voluble squabble in the United Nations Assembly between Afghanistan and the Republic of Ecuador, some hot-headed Afghan

soldier set off a thermo-guided atomic missile in the great Hindu Kush missile base. The missile, inexpertly aimed at Ecuador, took an erratic course and unfortunately was affected in its flight by a huge fire raging at the moment in a San Francisco warehouse. As a result, it swerved northward, and finally becoming influenced by the great fires at the steel furnaces of Chicago, made straight for that unfortunate city. Parts of Chicago were badly damaged but evacuation of its remaining population was accomplished in a few days by heroic efforts. Thus, this great city was left for posterity relatively intact in many areas, though full of evidence of the haste and disorganization which had accompanied its abandonment. Other great cities took the logical hint from this experience. As we in the year 6943 view the site where formerly stood the great city of Chicago we are impressed with the effects which a few thousand years have had in covering and burying what once was a bee hive of political, industrial and educational activity. Decay, corrosion and theft have deprived us of much of the readily accessible materials important to the research worker interested in that period.

Rocket Tunnel

Construction activities in connection with the new transcontinental rocket tunnel very fortunately turned up some fascinating artifacts in the area of old Chicago. My accomplished pupil, Dr. Johan Bjorksten, who has specialized in chemical and physical methods as applied to the archeology of early American industry, has made an interesting analysis of a variety of plastic artifacts which he has uncovered in his diggings. The evidence he presents seems conclusive and if so, the plastic age must have been born, developed and reached great applicational maturity in an incredibly short space of time when compared to the metal age and the stone age which preceded it. Without further words, it is my pleasure to present to you Dr. Bjorksten, who has flown here directly from his diggings to give us the pleasure of hearing of his exciting discoveries. Dr. Bjorksten.

The Plastics Age

Ladies and Gentlemen:

As Professor Bookbrowser has indicated, the transcontinental rocket tunnel pierced the site of the former city of Chicago during the construction operations about five years ago. In the interests of archeological studies of early industries and arts, the digging equipment carried apparatus for the examination of the removed material, continually recording the density, moisture content, hardness, as well as the conductivity, dielectric constant and isotopic composition of statistically significant samples. It was my privilege to have charge of the analysis of the chart recordings of the automatic instrumental testings, and you can imagine my joy at the discoveries made there regarding the objects belonging to the earliest years of the plastic age.

Press reports have no doubt informed you of our discovery of quantities of pure polystyrene, a plastic which has not been used in this pure form industrially for several thousand years. This finding at once showed us the antiquity of the site through which the tunnel was passing. So attractive was the area to me that I left the tunneling machine at that point and devoted myself to more minute investigations, by hand implements, of the deposits containing these interesting early plastic objects which made this area so rewarding.

Early Plastics

Naturally, investigations by manual processes are slow and tedious but they have the advantage of thoroughness, even if the area explored is necessarily small. Destruction of specimens is also less likely to happen. One of the most prized discoveries was a piece of very early phenolic, "Bakelite," now the earliest known plastic article of the non-cellulosic and therefore permanent types. This priceless object has been sent to the Central Museum for Industrial History. Other examples of phenolics of the pre-Carbide days, were also discovered and have been carefully studied for the light they shed on the dawn of the plastic age.

It had been regarded as a fundamental truism that simplicity of structure is the mark of great industrial antiquity. Thus, everyone believed that the earliest plastic must have been one of the polyethylenes because of the chemical simplicity of these materials formed, as they were, from such a simple molecule merely by heat and pressure.

These finds show that the polyethylenes were preceded as much as half a century by phenolic plastics, and that both acrylates, alkyd resins and amine-aldehyde resins occured earlier than the first finds of polyethylenes. The epoxy resins made their appearance within the following decades.

In presenting our findings, we have the choice of several procedures. We could arrange the material by applications, by chemical nature, or simply chronologically, by the age of the specimens as determined by the layer in which they were found, or by their isotopic composition. I shall try to describe to you the main trends of development, as they seem to have occurred, but because of the extremely short span of time into which the development was compressed, some jumping from subject to subject is unavoidable.

Development

Taking the broad view, we can distinguish the following main lines of events in the plastic development:

The trend toward increasing size.

The trend toward increasing strength of materials.

The trend toward differentiation between structure in outer and inner layers of articles.

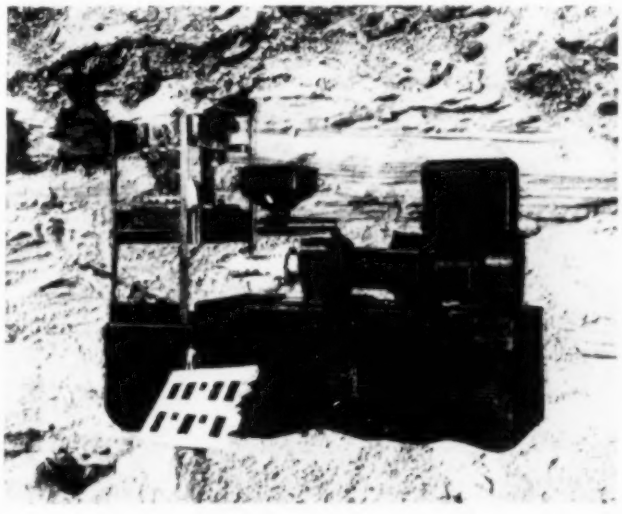
The trend toward differentiation between chemistry of outer and inner layers of articles.

The trend toward increasing number of polymers available.

The trend toward increasing scope of applications.

These trends all depend on each other. For example, the increases in size became possible through improvements in engineering practice and equipment, as well as through increased strength of materials, and these, in turn, came about through structure differentiation, and chemical development.

While the qualitative improvements took place at a fairly constant rate between 1920 and 2100, the volume of production, as we judge it from the number of specimens dated to any particular year, moved in sudden spurts. Such spurts occurred, for ex-



Injection molding machine excavated at site, with broken section of wall-panel of two story house.

End of ruptured tunnel with preserved vehicles.

ample, when about 1970, the glass filled laminates exceeded steel in strength, when around 1990 the fertilizer industry began to utilize its fluoride by-products for plastic production, bringing about low cost fluorinated resins, and again when the polyphenols became cheaply available from the chemurgic forest industry lignin.

We shall return to these turning points later.

Between 1930 and 1950 a good number of plastics had made their appearance, including, for example, melamines, allyls, epoxy resins, silicones, siloxanes, fluororesins, methacrylates, and presumably the less stable and therefore not preserved butene sulfones and vinyl chlorides. Being already familiar with alloying techniques from their metal technology, the plasticians of that day were quick to grasp the possibilities of not only copolymerization, but particularly of intermingling procedures which gave commingled atomic lattices, and thereby increased strength and tenacity.

The greatest progress in mechanical properties came about as the fillers were perfected.

About 1950 the glass filled laminates apparently began to be used mostly for relatively small items such as cabinets, boats and military implements. The discovery of treatments to effect a moisture resistant chemical bond between filler and alkyd type plastic must have taken place about that time, for the number of applications, and size of the specimens both increase dramatically during the following decades. Since these specimens contain organic resins, it is easy to date them with an accuracy of about 5 years, by the use of refined isotope techniques.

About 1970 the strength of the glass filled laminates had reached the stage where they surpassed steel in tensile strength. Rigidity of the structure was made comparable to that of steel by improvements in resin, bond and filler, but quite particularly by ingenious design techniques. These advantages held true not only on a weight, but also on a cost basis. Only thus can we explain the prevalence of these plastics from that time on in an age when rich iron ores were still abundantly, though distantly, available without resort to expensive deep mining techniques.

As soon as the rigidity problem was solved, it appears that these plastics became standard in automotive and constructional parts, where the weight advantage was important as well as low cost and freedom from corrosion. Bridge design was changed drastically. A steel cable 7 miles long would break from its own weight, and so the silicon and fluoro plastic protected glass cables were destined to play a key part in the deep mining techniques, which came into play when the surface deposits of valuable minerals had become exhausted through the reckless exploitation of the early industrial era.

Glass Laminates

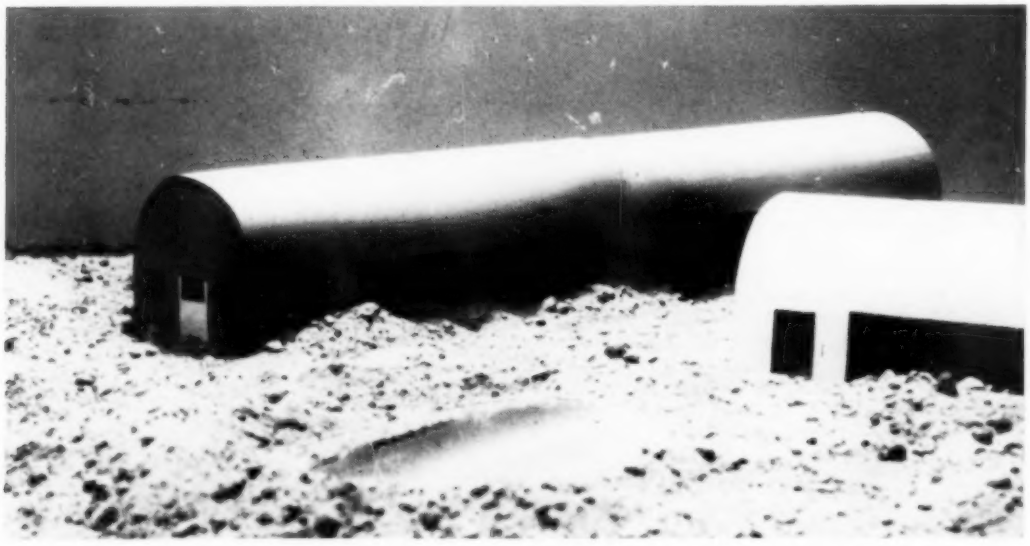
The techniques developed for glass lamination had also found their uses in both extrusion and injection molding. Fibers, surface treated to present surface layers directly copolymerizable with the plastic used, were intermingled as a part of the plastic granules. Once the problems of flow characteristic were solved, this technique made it possible to produce by injection molding and extrusion, objects of mechanical properties approaching, if not equaling, the properties of the laminates.

Along with these refinements, the dimensions of the injection molded specimens increased at a steady rate during the 21st and 22nd centuries. The very oldest specimens are small enough to hold in the hand. Around the middle 1950's we find considerable furniture and cabinets made by injection molding. Around 1970 the use of house components such as reinforced beams, wall panels, etc., become frequent, as illustrated, for example, in the Figure 1. We see here, leaning against the press, a wall panel for a two story dwelling. The injection press in the photo was also tooled up to produce house components.

The application of extrusion techniques for filled materials is illustrated by the photograph of an old traffic tunnel.

This tunnel was severed in the catastrophe Professor Bookbrowser referred to. As we uncovered the opening, the cars in the tunnel and the remains of their occupants, were recovered and are here photographed in their original state. This traffic tube was made by extrusion of a mildly crosslinked polyethylene, using as fillers carbon black and glass fiber, to the extent of 45% of the total weight.

By the way, among the bodies found in this tunnel, and protected from decay by radioactivity of sterilizing intensity, we found one which had a large scar about his left hip, obviously from a surgical operation. On dissection, my distinguished friend, Dr. Bonebridge, found that this body had the left half of his hip bone made of a cross-linked poly-



This view is of low-cost housing units formed by extrusion. The extruded tubes were then sealed and finished.

amide plastic. This plastic part of the large bone was glued to the other half of the bone by means of a cement, which proved to have a phosphamid polymer structure. Apparently the phosphorus atoms provided the necessary affinity to the calcium phosphate of the bone structure, while the amide part of the cement adhered to the polyamide plastic, resulting in a unitary structure as strong or stronger than the original bone.

Plastic Houses

Housing was a basic requirement of the human race then, as it is now, and it was but natural that the newly acquired skill in the making and handling of plastic, should be turned to this basic need. The work on extrusion and on injection molding of components had paved the way, and by 2028 we find the first house which had been injection molded in its entirety. Reinforcement gave strength, foaming gave insulation, and by combining the two with a mass production technique, it was now possible to produce better housing than the average man had ever known before, in 2 or 3 operations and using very few tons of plastic.

In the upper strata of Chicago, say corresponding to 2050 till 2150, we find predominantly three types of house structures: the low cost housing, made by extrusion as tubing, and then caused to sag along two seams by the application of heat rods to the floor, so as to produce a semi-tubular structure. This was the low cost housing of those days. As the medium range, injection molded housing made from glass or polyamid fiber reinforced polystyrene co-polymers permitted rapid production and at the same time conformance with traditional house forms, to which the population seemed to cling from traditions, long after any engineering reason for these particular forms had ceased to exist.

Glass laminates from styrene-alkyd, fluoramide, or epoxy resins were more adapted to individual custom design, and represented the luxury housing.

Insulation

One of the photographs shows one of the low cost structures, just mentioned. The main body of the housing was made by extruding a transparent plastic of hydrocarbon type. This plastic was then exposed to flash heat from the inside, which caused the volatile constituents present in the extrusion mix to boil, so as to create a foam structure in the inside part of the wall, while the outside layer remained a hard and mechanically very resistant skin. The building was then spray painted on the inside, with a highly resistant polyphenol type finish, carrying the desired pigments. For windows, the original clear plastic was preserved in the desired window areas, simply by applying masks of insulating tape, which reflected the heat applied in the foaming step and masked off the paint spray, so that the original clear plastic was preserved in these window areas. Molded side walls were used to seal off the ends of the tubular structures.

The only portion of the houses which were not molded in the single operation were radiant heating arrangements. Subsequent to about the year 2000, the most frequently encountered heating arrangement was a ceiling structure composed of a tubular arrangement of polyfluorohydrocarbon co-polymers. These plastics offered a possibility of circulating heated water at temperatures where many other plastics would suffer from creep, and at the same time comprised perforated members, acting as acoustical ceiling, and permitting air flow for ventilating purposes. You might be interested in a few words concerning the high temperature resistant plastics of silicon or fluoro type, and how the latter type came to be adopted for radiant heating purposes.

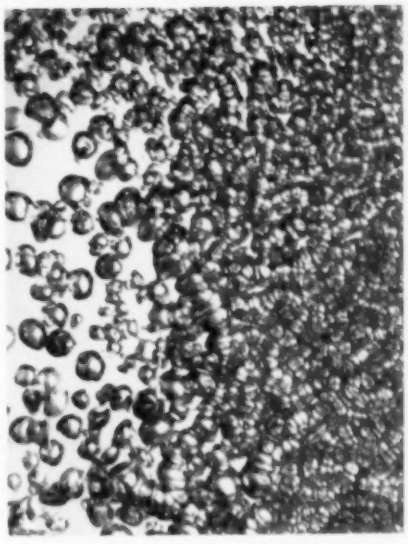
Silicon Plastics

The silicons were in evidence already in the middle of the 20th century, but at that time chemical production limitations may have made them expensive, and carbon from natural sources was still so abundant that the incentive to use the more abundantly available silicons as base for a technology did not exist then to the same degree as it did in later years.

The fluorinated materials were scarcely in evidence until 1980, when they suddenly appear on a substantial scale, particularly in airplane and vehicle parts, where some high temperature resistance together with increased mechanical strength appeared desirable. Based on correlation with studies elsewhere, it is our belief that the appearance of the fluorinated plastics on a large scale, coincided with the adoption of methods for economical recovery of fluorine from superphosphate fertilizer production, where it had previously gone to waste.

I already meationed the use of fluorinated plastics in the field of radiant heating, and it also gained importance in high speed transportation where heat due to air friction precluded use of less heat resistant plastics.

As large markets appeared for the fluorine products of superphosphate fertilizer industry, the firms manufacturing fertilizers began to buy heavily into the plastic field. They had already become familiar with this field from another standpoint, inasmuch as the commercial use of resinous polyelectrolytes, which today is



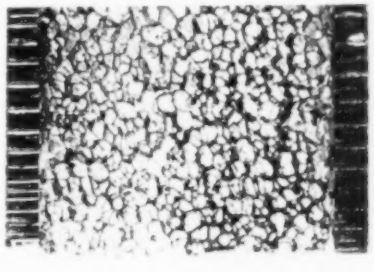
Section of house wall with bubbles for insulation induced by unilateral heating

essential in all farm soil treatments, dates back to the 1950's.

Research sponsored by the fertilizer companies brought about the utilization of both silicons and fluorine by direct reactions involving silico-fluorides. Thus were created the "siloflor" resins, and a new path of effort was found. These developments finally led to the polysiloflorinol amides, which became the basis for the "eternity paints" so well known to archeologists working with artifacts later than from the 24th century.

There is a good deal of evidence that the vinyl chloride, as well as the still lower priced butene-sulfon resins, already enjoyed considerable popularity at this time. However, these low cost resins were not at that time stabilized to the point of endurance through millennia, and therefore we do not have samples preserved from those early days. The chlorine content of dust in the interior of many habitations might indicate, however, that vinyl or vinylidene chloride, or their co-polymers, were already then employed in draperies and household articles, as they are now.

(continued on page 12)



Reinforced plastic foam from wall structure of plastic house.

Plastic Panel Surface Case-hardened by diffusion of cross-linking agent from external area.

While the phenolic resins had increased in occurrence all along on a quantitative basis, their occurrence as a percentage of all resins had been receding, due to the spectacular increase in the use of thermoplastic resins in the 20th and 21st centuries. This trend was accelerated by the perfection of crosslinking agents for thermoplastics, which could be activated after molding either by curing or by chemical diffusion, or radiation. In this manner, the materials could be extruded or injection molded as thermoplastics, but could then be caused to crosslink, so as to acquire the heat distortion resistance of the thermosetting resins.

Thermosets

The comeback of the thermosetting materials did not materialize until the end of the 21st century, when we find a larger percentage of samples of phenol based plastics, this time based on polyphenols such as resorcinol, pyrogallol and their isomers. A detailed analysis of the impurities present in these resins leads us to conclude that they were prepared from lignin, and indeed, their prevalence in the next centuries follows closely the expansions and contractions of chemurgical forest industry.

In studying the smaller injection molded artifacts, we soon found it possible to date them without resort to the tedious isotope technique, merely by study of the mechanical structure. The oldest specimens, say up to 1955 or so were usually uniform throughout; even the color was evenly dispersed throughout the mass. As the size of the articles increased, greater differentiation in structures became mechanical and an economic necessity. Color is imparted by surface coatings, which fuse with the plastic to a unitary body, which cannot be parted by mechanical means. The seemingly contradictory requirements of surface hardness and mar resistance, together with freedom from brittleness and high impact strength are met in three ways: by surface coating a tough inner core of inexpensive plastic such as butenesulfon, polystyrene, etc., with a fused outer layer of extremely hard and mar resistant allyl or polyphenol resin, or equivalent; or by interdiffusing a crosslinking agent from the outside, so that a hardened surface layer surrounds the more tenacious core; or achieving a similar effect by including the crosslinking agent and an inhibitor of this agent in the original molding mix, and then inactivating the inhibitor by means of low molecular ozonide diffusing in from the surface.

When filled injection molded specimens appear, the arrangement of the filling is a good index of the advancement of the art at the time the article was made and permits us to date the article. The earliest artifacts show a random arrangement of the filler, and poor adhesion between filler and plastic. Subsequent to about 1950, the filler was treated to give good adhesion, with resultant improvement in strength. In the following decades, attempts became evident to achieve orientation of the reinforcing fibers, by means of multiple orifices in the molds, to set up currents and flow lines for orienting the suspended chopped reinforcing fibers in certain planes or patterns for optimum strength. The skill of mold engineering for achieving the best distribution of reinforcement increased steadily during the following fifty years, until the advent of magnetic glass made possible the utilization of magnetic fields to achieve perfection in this regard. This "magnetic glass" was made by surface absorption of magnetic films to micron size glass, polyamide or siloflor fibers.

Art Relics

Little has been preserved of the art of the early plastic age, and from the specimens you have seen so far, it would seem that the energies of the people at the time were almost entirely absorbed in mastering a new technology; that their art had not kept pace with their engineering. However, this review would be incomplete if I failed to mention one outstanding exception.

This painting, signed by Glasier, has been dated by isotope analysis to 1950. We cannot know just what the artist had in mind, what traditional or ceremonial significance his contemporaries may have given it. But looking back through the millennia, I like to think that his work of art symbolizes the state of the plastics industry at the time when it was painted. It was an infant then, but with eyes wide open, just awakening to awareness of its great powers. It holds two symbols; a primitive ray gun, signifying military applications, which in the century following matured into patterns the contemporaries of this painter could hardly have imagined; and in the other hand, a budding flower, signifying the peaceful applications which made man all but independent of metal ores, and furnished the structural materials without which the world we know today could never have become a reality.

Early painting by Glasier.

In looking back through the millennia, we must admire the ingenuity and resourcefulness of those early engineers, who in two centuries brought a new age into being, who in a spurt of creative energy unequalled earlier or later in man's history, gave us the materials, and the mastery of their use, which made an era of peace and plenty for all.

SPEC Meeting

The American Association of Spectrographers is planning a symposium on "Instrumental Methods of Analysis in the Non-Ferrous Industry." This will be held in Chicago in May, 1952. Contributed papers in this field are welcome. Please address all inquiries to: Robert Raisig, c/o Apex Smelting Company, 2537 W. Taylor Street, Chicago 12, Illinois.

EXTRUSION OF VINYL FILM

Albert M. Stover
Naugatuck Chemical Division
U. S. Rubber Co.

Blow molding of very thin vinyl film is now possible, opening up new uses for this versatile material by cutting cost per square foot.

Introduction

A brief review of some data will emphasize the possibilities offered by this new industrial development. In the year 1950 over 100,000,000 pounds of calendered vinyl film were produced and consumed in this country. This compares with about 27,000,000 pounds in 1947. It is almost impossible to visualize the potential increase in the film market if the price per square yard of film could be reduced to one-half or one-quarter of present prices.

As the consumption of film increased, the industry trend was constantly towards the manufacture and sale of the thinnest possible gauges obtainable on calenders. However, most calenders today cannot produce film below 3.5 mils in thickness because of equipment limitations; as far as is known, no calenders are producing film commercially below 1.7 mils. Hence, the price per square yard, which is tied in with the price per pound of compound, has reached a bottom limit for most calender operators. In this talk, a process will be described whereby vinyl film or sheeting can be produced in any desired thickness ranging from .020" on down to .001", or even as thin as .0003". Continuous film over 100" wide can easily be obtained. The largest potential for this process seems to lie in film in the range of .003 and below. Although the pound cost of the thin gauge film may well be as high or higher than film made by other processes, the cost per square yard should be approximately proportional to the thickness, and therefore less expensive.

Very Thin Film

Before the technical aspects of this process are covered, it might be helpful to discuss the usefulness of, and possible markets for very thin film. One very obvious end-use, of course, is in packaging applications of all kinds, since it acts as a barrier to furnish protection against water, grease and dust. Film of this type should find universal acceptance in the households of America for a number of uses such as the storage of clothes in all seasons in dust-proof and moth-proof enclosures. When traveling, white shirts can be kept immaculately clean in the suitcase, while dirty shoes can be kept from

A. M. Stover

soiling other articles of clothing. It should find use as water-proof and grease-proof film for use in the kitchen; for example, it serves very well as a disposable garbage pail liner. An inside lining of plastics converts any cardboard or wooden box or even paper bag into a water-tight container. A water-tight plastic container can be fabricated by the very simple process of tying a knot in one end of a thin-walled vinyl tube. Outdoors, large sections of film might be effective in keeping birds from substituting freshly planted grass seed for insects in their diet; it should also protect flowers and vegetables from unexpected late spring or early fall frosts. On camping trips, it can serve to keep grass stains and grass dampness from one's clothing. It would be possible to go on endlessly outlining the possible uses for materials such as this. The fact that it can now be made thinner than ever before, and yet serviceable, will enable it to be sold at a price attractive to the modern housewife who has an eye for a bargain and can compare the advantages of a material such as this in competition with cellophane, wax paper, thin fabrics and other materials of similar gauge.

It is in order at this point to review briefly the history of this development to date. Polyethylene has been successfully extruded for some years by the process of "blow extrusion." Initial attempts to manufacture vinyl film commercially by the same process failed for a combination of three reasons — inadequate equipment, unsuitable compounds and most particularly, lack of technique. Members of our staff became enthusiastic about the possibilities of the extrusion of vinyl some time ago, and embarked on a program to determine the technical and economic feasibility of the process. It is necessary to develop very high tear strength in the film to enable it to be used in very thin gauges. Extremely high processing temperatures are necessary to develop maximum tear strength. Therefore, as a first requirement, a resin of very high heat stability is needed. The second requirement is that the resin extrude smoothly and without nerve. Thirdly, a high extrusion rate is extremely desirable to obtain the highest possible production output in pounds per hour. In Marvinol VR-10 we were fortunate in having a resin which is uniquely suitable for this process since it is widely recognized as meeting all three of these major requirements. First, it has excellent heat stability, which is partly due to the fact that it is the highest molecular weight general purpose vinyl chloride resin now being used in this country; second, calendered sheets or extrusions based on Marvinol VR-10 are remarkably free of waviness or roughness usually associated with nervy stocks; during processing these compounds are extremely flat and nerveless; third, the higher output in pounds per hour obtainable from extruders when Marvinol VR-10 is used as the vinyl resin has been reported repeatedly by the trade over the last few years.

Equipment Needed

Most of you are interested in the equipment necessary to produce blown extruded film on either a laboratory or plant scale. Equipment cost data, operating techniques, formulations, and physical properties of the end product may also be of interest.

For basic machinery to manufacture film you will need:

1. Premixing equipment for preparation of feed to the extruder.

2. An extruder equipped with a film blowing head.

3. Take-up equipment for rolling up

the film.

4. Least expensive, but not least important, "die dismantling" equipment.

Die dismantling

This last item is most necessary for development work. Sometimes experimental compounds do not always behave as expected. As most of you know, polyvinyl chloride compounds, like most organic materials, will decompose if excessive heat is applied for too long a period of time. The degradation of polyvinyl chloride can become autocatalytic and can release large quantities of hydrochloric acid gas. The carbonaceous residue tends to adhere very tightly to the acid etched metal, so it is best to avoid this situation. We found that it was necessary to devise a means of getting the film blowing die apart in a hurry when trouble occurred, as well as when any successful run is terminated. In our first attempts, we made a table small enough to put under the die and placed an automobile jack thereon. We then tried to force the core pin out of the die with the hydraulic pressure exerted by the jack. We soon found that the adhesion of the compound to the die and the core pin was such that the hydraulic jack simply raised the extruder off the floor in preference to pushing out the core pin. We overcame this difficulty by the use of a $\frac{3}{8}$" thick annular steel ring with diametrically opposed slotted ears. This is placed on top of the die, around the rim, but clearing the core pin. This is attached by chains from the ears to the table holding the jack. The jack is used to force a cylindrical steel tube against the bottom of the mandrel or core pin to force it out. After a little experience, it was found possible to get the die assembly apart in a matter of a number of minutes instead of a number of hours, which was required when we first began our experiments.

Blowing

In the start of the operation the tube is pinched off and the extruded tube is then inflated very slightly with air and the end is passed through two squeeze rolls. This effectively seals the upper end of the tube. At this point, additional air is introduced through the die which causes the tube to expand to size. This expansion must be carried out very slowly, or a tube with a very uneven diameter will result. When the desired degree of expansion is reached, the air supply is shut off and the continuous production of film is in process. The air is sealed in between the nip rolls at the top and the die at the bottom. To change the gauge of the extruded film, it is merely necessary to vary the speed of the take-up rolls. If, for example, the arrangement is such that 4 mil film is being produced with a given set of conditions, it is possible to change very quickly to 2 mil film merely by doubling the speed of the take-up rolls, thus drawing the material away from the die at twice the rate causing it to thin down from the former thickness. To change to 1 mil instead of 2 mil film, it is merely necessary to double the take-up speed again, while $\frac{1}{2}$ mil film can be made by a further doubling of the take-up rate.

When starting up operations we find it advisable to run with a large amount of bleed stock to prevent initial hang-up in the die. Once the stock is flowing freely throughout the extruder, the bleed can be cut back to a minimum. A small amount of bleed helps prevent stagnation in the head. We usually find it advisable to start with a die temperature 20-30° lower than we use for standard operating conditions. Once the tube is formed, operating the extruder near maximum speed also seems to improve the flow characteristics of the compound and seems to prevent stock stagnation because of the high throughput. In our initial work in this project, we found it advisable to use highly stablized, overlubricated vinyl compounds until we had worked out the necessary operating techniques. Suggested formulations for preliminary experimental work are given in Table I.

TABLE I

	191-126
Marvinol VR-10	100.0
Dioctyl Phthalate	35.0
Dyphos	2.0
Tribase	4.0
DS-207	0.5
Acrawax C	0.5
Carnauba Wax	2.0
Titanoux RA-NC	12.0

	196-5
Marvinol VR-10	100.0
Dioctyl Phthalate	30.0
Dibutyl Tin Maleate	2.0
Calcium Stearate	1.0
Acrawax C	2.0
Mineral Oil	2.0

It is obvious that the plasticizer content used for very thin film is considerably lower than that used for the heavier 4 gauge film, which is usually about 45 parts on 100 parts of resin. These compounds will not yield entirely satisfactory film because of a waxy or greasy feel but they are recommended for determination of operating conditions and the development of the necessary operator technique. A general purpose film with a better appearance is given in Table II.

TABLE II

Marvinol VR-10	100.0
Dioctyl Phthalate	30.0
Dibutyl Tin Maleate	1.0
Advance #3	0.5
Calcium Stearate	0.3
Carnauba Wax	1.0

The following set of conditions were found suitable for the operation of our 1½" Modern Plastic Machinery Corporation extruder equipped with a 4" diameter die film head:

TABLE III

Extrusion Conditions

	Start of Run	**Main Part of Run**
Die Temperature, °F		
Core Pin	335-350	395-425
Die Face	335-350	395-425
Head Temperature, °F	350-360	380-400
Barrel Temperature, °F		
First section	350-360	350-360
Second section	320	320
Screw Speed, RPM	40	40
Screw Temperature	Not checked*	Not checked*
Hopper Temp.	Not checked*	Not checked*

*Ambient temperature. Neither water nor steam used.

Table IV contains physical test data on film samples prepared in our laboratory. The extruded 2-mil film was extruded at 420°F while the calendered film was prepared at 320°F. You will note that the higher processing temperature has contributed to the higher physical properties of the extruded film. The higher tear strength is particularly outstanding.

TABLE IV

Comparative Physical Test Data on Laboratory Calendered and Extruded Film

Formula Based on 100 Resin and 45 DOP

	Calendered 2 mil	Extruded 2 mil
Processing Temp.	420°F	320°F
Tensile, lbs./sq. in	2600	2000
Elongation, %	170	120
100% Modulus	1800	1800
Elmendorf Tear, lbs. in.		
With grain	910	170
Across grain	980	360

Films containing this quantity of plasticizer tend to be too soft when they are as thin 2 mils, and a lower plasticizer ratio is preferable for many applications. In Table V the effect of lowering the plasticizer content from 45 to 30 parts of DOP per 100 parts of resin is shown. A decided increase in tensile strength and 100% modulus is observed, and a decrease in the Elmendorf tear strength reading.

TABLE V

Comapartive Physical Test Data on Extruded Film with Less Plasticizer

Resin to Plasticizer Ratio	100 Resin: 45 DOP	100 Resin: 30 DOP
Tensile, lbs. sq. in	2600	4600
Elongation, %	170	220
100% Modulus	1800	3100
Elmendorf Tear, lbs. in.		
With grain	910	340
Across grain	980	670

Some plastics lose their strength

(Continued on Page 24)

HIGH IMPACT

STYRENE and COPOLYMERS

Paul M. Elliot

Naugatuck Chemical Division
U. S. Rubber Co.

The development of heat-resistant styrenes, and tough styrene-copolymer resin mixtures is continuing.

Introduction

Ultimate progress in a given field is always a seesawing back and forth of individual developments of materials, processes, equipment, and end use products. New materials permit the application of different processes involving perhaps a type of equipment which may be entirely new or even borrowed from another technology. Then with the process and equipment available the end use products are developed. Deficiencies in these products or perhaps incomplete utilization of the possibilities of the equipment invite the development of new and improved materials and the cycle repeats.

Our present day plastics injection molding industry with its almost countless familiar end products is a stage in such a growth. The relatively heat stable cellulose acetate molding powders introduced in 1929 permitted application of the principles of the metal die-casting machine to the production of plastic parts. As the machines became available and were redesigned to function better with plastics, new molding powders were developed. The cellulose ethers, new and modified cellulose esters, polystyrene, and polymethylmethacrylate were all introduced in commercial forms within five years after the initial use of injection molding machines in this country in 1934.

Use Increase

In the early 40's much was done to improve the quality of these molding powders and a multitude of special types in an almost endless variety of colors was produced. The polystyrene powders advanced slowly. Initial production resins were not desirably uniform in appearance or in performance. However, intensive studies of production methods and equipment improved the product so that by 1944 almost four percent of this country's production of thermoplastics was in polystyrene. In the next four years, production of polystyrene advanced rapidly. The plants and know-how developed in the synthetic rubber program made available an abundance of pure styrene and together with

Paul M. Elliot

improved polymerization procedures permitted preparation of increased amounts of better polystyrenes at progressively lower relative cost. In 1948 over one-quarter of our thermoplastic production was polystyrene and polystyrene production amounting to some 150,000,000 lbs. was about twelve fold greater than in 1944.

This tremendous increase in the use of polystyrene did not indicate that it was the ideal plastic. It did have a valuable combination of properties: —high hardness, good dimensional stability since it contained no volatile plasticizers, excellent electrical characteristics, low specific gravity, excellent color and clarity, and of course—low cost. At the same time it had several deficiencies among which were two that showed up prominently in consumer use. First—it was relatively brittle; it lacked the toughness shown by the other familiar plastics and many polystyrene articles stood up poorly under what might be considered ordinary use. Second—the temperature at which it softened sufficiently to distort or lose shape was low enough (175-180° F) to be exceeded in many household and industrial applications. Even before general purpose polystyrenes were perfected, attempts were made to overcome these deficiencies.

As early as 1944 some progress was made in attacking the second of these problems. A new product **Cerex**[1] was put on the market which offered a considerable improvement in heat distortion temperature. The material, characterized by its manufacturer as a copolymer was available in a range of forms with heat distortion temperatures up to 230° F. The higher members of the series had poor flow and were hard to mold, but intermediate members, of excellent molding qualities, had high enough heat distortion characteristics so that molded parts could be expected to withstand temperatures of 250° F. It should be noted that the useful temperature limit of a product is usually quite a few degrees above the arbitrarily determined "heat distortion point." The composition of **Cerex** was not disclosed; however, as an indication of how much a modification may have been accomplished we can refer to work published by Staudinger in the middle 30's which indicates that copolymers of styrene and divinylbenzene offer such properties. Small amounts of divinylbenzene in the copolymer would give increased heat distortion, modulus, and solvent resistance without seriously altering other properties.

Heat Distortion

Another approach to the same problem of improving heat distortion is found in the polymers of dichlorostyrene, two of which, **Styramic**[2] and **DCS**[3] were put on the market in 1944. One of these products had a heat distortion point of 236° F. However, polydichlorostyrene is not a polymer or copolymer of styrene but is rather a styrene derivative.

In 1946 **Plexene M**[3] a copolymer of styrene and acrylonitrile was put on the market. It offered improved heat resistance, greater strength, improved weathering, and a small increase in toughness or impact stren-

(1) *Monsanto Chemical Company*

(2) *Mathieson Alkali Company*

(3) *Rohm and Haas Company*

gth. Since then two other styrene-acrylonitrile copolymers, **C-11**[4] **and Kralastic**[5] have been put on the market.

Mixtures

In 1947 **Lustrex**[1], characterized as a modified polystyrene, was offered to the industry. It gave a heat distortion point of 190°F, some ten to sixteen degrees higher than standard polymers, and at the same time offered improved flexural strength and improved impact. The difference in impact was not large, being somewhat less than a 1 ft. lb. increase in an unnotched test comparison, but it was a step in the right direction.

Two separate developments evolved in 1948, both of which utilized a new basic principle—namely, that suitable mixtures of properly designed resins and rubbers would show hardness and heat distortion point characteristics approaching those of the resin, and toughness and brittle point characteristics more like those of the rubber.

Blends of high styrene-low butadiene resins with GR-S type rubbers were shown to possess high impact strength but, unless cured, gave low flexural strength. As a result injection molding applications were limited to parts wherein flexural strength was of minor importance. Most applications of these high styrene-low butadiene resins blended with rubbers have involved cured or thermoset compounds. Even then the end use has been limited by the low heat distortion temperature of the blends, which in typical compounds was in the range of 130-140°F.

Rubber-Resin

The second type of resin-rubber blend was based on styrene-acrylonitrile resins and butadiene-acrylonitrile rubbers. Once again the products possessed unusual toughness. The high heat distortion characteristics of the resins, which had heat distortion temperatures in the range of 195 to 210°F, permitted general use of the blends without curatives and the compounds had both high impact and good flexural strength. However, when first announced these materials were available only in the form of fabricated parts or sheet stock, under the trade name **Royalite**[6]. They were not sold as injection molding powders.

Further advances in styrene plastics were registered in 1949 with the introduction of specially modified polystyrenes designed for heat resistance, others designed for improved toughness, and of molding powders based on the acrylonitrile resin-rubber blends.

(4) *Bakelite Division, Union Carbide & Carbon Corp.*
(5) *Naugatuck Chemical, Division of United States Rubber Company*
(6) *United States Rubber Company*

One of the two products, **Polystyrene 8**[7] and **Styron 671**[8], to which improved heat resistance was attributed was said by the manufacturer to be prepared by methods which permitted accurate control of both chain length and chain type. Simple increase in molecular weight did not give the desired effect. Shortly before this time extensive rather basic studies of the polystyrene system in a number of laboratories had demonstrated that complete removal of unreacted monomer or low molecular weight polymer, and control of molecular weight distribution, branching, crosslinking etc., in the remaining polymer permitted significant improvements in resistance to crazing, solvent resistance, impact, and tensile strength. Apparently commercial application of this fundamental knowledge bore fruit in the improved polystyrenes.

Elongation

Styron 475[8] was a new, tougher polystyrene introduced in 1949. It was the first of several similar materials featuring increased elongation and greater toughness or impact resistance relative to general purpose polystyrene. Others including **Lustrex LT**[1], **Molding Compounds 201** and **301**[7], and **QMS 151, 152, and 155**[4] have appeared during 1950 and 1951. Table I presents a comparison of averaged data for these modified impact polystyrenes and for general purpose polystyrenes. In general, the modified products show somewhat lower tensile and about ten times as high an elongation as the polystyrene. They have three times the impact; with one exception they have about the same heat distortion temperature; and they are slightly softer than standard polystyrene. No published reference to the composition of these products has been found but general properties plus the fact that they are opaque indicates that they are probably combinations of selected polystyrenes with a plasticizing copolymer of more or less rubbery nature and that they contain lubricants internal, external, or both. Relative to standard polystyrenes they offer significant improvement in impact and elongation.

(7) *Koppers Company, Inc.*
(8) *Dow Chemical Company*

An even greater advance in toughness was shown by **Kralastic**[5] a new molding powder based on a resin-rubber blend similar to that used in the **Royalite**[6] which had been made available as sheet stock in 1948. This molding powder introduced in 1949 was prepared by blending a resinous copolymer of styrene and acrylonitrile with a rubbery copolymer of butadiene and acrylonitrile. It can be readily understood that a molding powder based on such a blend should be subject to a wide variation in the properties of the product. The ratio of nitrile in the resin and rubber, and the ratio of resin to rubber in the final mixture are but primary variations and a multitude of secondary variations can be imposed on this already flexible system.

Kralastics are currently available in three main types, the B, D, and F series of molding powders. Two of these series are also available in specially lubricated modifications known as BE and FE series which are particularly suited to extrusion processing. Table II shows average data on some of the physical properties of the three classes of compounds. The Kralastic BM series of compounds features maximum impact strength with good molding charateristics. Kralastic D compounds feature very good molding characteristics, good surface finish, and maximum hardness, stiffness, and strength. Impact is lower than for BM compounds but the D compounds are still

Table I

	Averaged Properties Modified Impact Polystyrenes	Averaged Properties Standard Polystyrenes
Tensile psi	5000	6500
Elongation %	20	2.0
Impact (Cut Notch) ft. lbs.	1.0	0.35
Heat Dist. Temp. °F	180°*	180°
Hardness, Rockwell	R-95	R-120

*Except for one type, which is about 160°F

Table II

	Kralastic Type		
	BM*	D	F
Tensile psi	4500	6500	4000
Impact (notched) ft. lbs	8	0.8	5
Heat Dist. Temp. °F	180°	187°	180°
Flow Temp. °F	305°	280°	280°
Rockwell Hardness	R-95	R-109	R-92
Colors	Opaque	Opaque	Opaque

*The injection molding grade B compounds

very tough. The Kralastic F compounds are a compromise between the BM and D materials. They have better molding and surface finish characteristics than BM stocks and are tougher but softer than the D stocks.

In Table III are presented data for some of the electrical characteristics of the Kralastics. Although the inclusion of acrylonitrile in the system has reduced electrical characteristics somewhat the compounds still have very good properties.

Impact Tests

As is well known in the industry the interpretation of laboratory impact tests in terms of service performance is difficult. Recent literature seems to include more and more frequently impact data with molded notch or no notch at all in place of the standard milled notch. There is some indication that perhaps these results correlate better with performance than the standard milled notch test. The tests lead to different interpretations anyhow. In Table IV are presented data on notched Izod and unnotched Charpy impact tests run on a number of types of injection molded test bars. It is notable that the unnotched test shows unexpected spread between the standard or heat resistant polystyrenes and the styreneacrylonitrile copolymer resins. On the other hand it decreases the change from most brittle to toughness compounds which show a 25 fold difference in the notched test but only a 6 fold difference in the unnotched test. Decision as to which test is the more significant will have to be based on more extensive data than are now available.

A new approach to the problem of increasing the impact of injection molded polystyrene was proposed early in 1951 in the suggestion that styrene impregnated glass mat might be injection molded. Experimentally it has been found feasible to injection mold styrene loaded glass mat. Best results have been obtained by feeding $\frac{1}{2}$" squares of the impregnated mat directly into the molding machine cylinder. Table V indicates the range of properties that has been obtained. The development is still in its infancy and much must be done before its potentialities can be determined.

From the data now at hand it appears that although some advances have been made in improving the toughness of straight polystyrene, the greatest advances have been made in the field of copolymers. By selection of the proper materials to copolymerize with the styrene and by suitable compounding of the resultant copolymers it has been possible to produce molding compounds which are not only tougher than polystyrene, but also have increased resistance to distortion at high temperatures, high hardness, good electrical properties, and very good chemical resistance. The many different angles of approach to the problems of harder, tougher, more heat resistant molding compounds offer the injection molder a wide choice of materials which opens new fields to his products.

Products

Injection molded helmets, golf club heads, carrying cases, and kick plates are replacing leather products. Injection molded cams, gears, pipe fittings, chair parts, doorknobs, shower and spray nozzles, floats, valve parts, machine housings, and small machine parts are displacing metals. Injection molded end caps, bobbins, spools, quills, etc. are replacing hard wood parts. The same molding powders are being used to extrude a wide variety of tubes, rods, and special shapes for use in pipe, duct work, cathode strips, machine parts, trim, table edging, stair nosings, etc. The new high impact styrenes and copolymers offer ever widening fields of application to the fabricator of plastic parts.

Acknowledgments

The author is indebted to the following men and companies for information furnished to him on current commercial products:—

Mr. Fred C. Sutro, Jr. ——— Bakelite Company
Dr. J. S. Whitaker ——— Bakelite Company
Mr. E. R. Nepkie ——— Dow Chemical Company
Mr. C. J. Snyder ——— Koppers Company
Mr. S. R. Melvin ——— Monsanto Chemical Company

Table III

	Kralastic Type		
	BM	D	F
Dielectric Strength	312	350	351
Volume Resistivity	1.8×10^{15}	10^{16}	1.1×10^{15}
Dielectric Constant 60 cps	4.76	3.41	4.15
3×10^{6} cps	2.76	2.66	2.70
Dissipation Factor 60 cps	0.021	0.009	0.015
3×10^{6} cps	0.006	0.003	0.006

Table IV

	Notched Izod Impact—ft. lbs.	Unnotched Charpy Impact—ft. lbs.
Std. and Heat Resist. Polystyrene	0.2-0.3	5-8
Styrene-Acrylonitrile Resins	0.2-0.3	12-14
Modified Impact Polystyrenes	0.5-1.3	16-21
Kralastic D series	0.5-0.6	22-26
Cellulose Acetate Butyrate	6.1-6.2	28-30
Kralastic F series	4.0-5.0	28-39
Kralastic BM series	6.0-7.0	40-44

Table V

Injection molded chopped polystyrene coated glass mat.	
Tensile psi	11,000
Elongation %	1.5
Impact (Notched) ft. lbs.	1.2-1.8

NEWARK

(Continued from page 21)

strated some of the physical properties of the epoxy resins and showed samples of the results obtained when using the resins as stabilizers for vinyl, polymers and adhesives in the metal fields.

The other speaker of the evening was Mr. J. T. Leyden, Service Engineer, Crucible Steel Co. of America, Syracuse, N. Y. Mr. Leyden spoke on the "Use of Prehardened Steel for Injection Molds." Mr. Leyden showed slides comparing the characteristics and machinability of various steels commonly used for plastic molds. After his talk, a very interesting discussion period was held with many mold makers asking questions regarding the impurities often found in large castings and what was being done to improve same. Mr. Leyden reported that the steel companies are continually checking castings for impurities and striving to reach perfection.

The next meeting was held on February 13, 1952 and Mr. James Bailey, Vice President and Director of Research of Plax Corp. Hartford, Conn., spoke on "Extrusion of Thermoplastics." After the talk by Mr. J. Bailey there was a panel discussion, moderated by Mr. Gerard Heldrich of Gering Products on Extrusion Problems.

NATURALE TOOLS

Mr. Victor Naturale formerly of Fortney Mfg. Co. Newark, N. J. and more recently of R & E Mold & Die, Bloomfield, N. J. resigned from his duties of Tool Room Foreman at R & E Mold to join his brothers Anthony and Joseph and become an active partner of Naturale Tools, Inc., 51 Morris Avenue, Newark, N. J.

The Injection MOLDERSCOPE

By A. R. MORSE

President, Injection Molder's Supply Co.

Heating Cylinder Design

No phase of injection molding incorporates more unknown factors than the heating cylinder. In spite of what some expert may tell you, we still do not know exactly what takes place inside a heating cylinder as the thermoplastic granules change from individual particles into a molten mass. There is underway a controversy between John Muller Supt. of Plastic Engineering, Inc. in Cleveland and ourselves as to what is the proper design of a heating cylinder. Out of many hours of discussion and sketching up what constitutes the correct design of a heating cylinder, John has come up with one theory, and we have come up with another. In order to prove out which of us has the right idea, we are building two heating cylinders for the 32 oz. Watson Stillman machine which will be identical except for the basic difference which distinguishes the two idea. (Since John and I intend to win the 1952 SPE Technical Paper Contest with a paper on our heaters, we are not going to disclose more than a general idea of what we are trying to prove!)

If we are successful, and one of us is proven wrong, the outcome is going to have far-reaching effects in the injection heater design field. (If both heaters prove about equal in performance, we are going to be in a worse quandary than we are now about what constitutes correct injection machine heater design—but that is a chance we have to take.)

Capacity Vs. Storage

Basically our difference of opinion centers around two things—original melting capacity versus final storage capacity of ready to mold plastic. John wants to move the spreader forward. This will give the material more time to melt, but of course it will cut down on the available space to store melted plastic. We want to increase the storage capacity of the heater, so that we can run the front of the heater cooler, and have on hand a larger inventory of material in the molten state which is ready to mold, so that less heat is needed as the material gets ready to leave the heater. We both wish to eliminate mica marks, produce better parts of less strained material which will stand up better in use because the material was not degraded in molding. (Degrading as currently defined means exposure of plastic to a heater surface which is so hot that even momentary contact burns, gases or otherwise injures the plastic. At the next shot, this degraded or burnt material is swept along, mixing with the cooler layers beneath, and finally appears on the surface of the molded part as mica, fish-scales, or other surface defect.) The experimental heaters — mammoth things over a yard long, are well underway, and we are anxious to get comparative data on them.

Starved-Weighed Feed

The matter of starved-weighed feed is going to be of tremendous importance in the injection industry. In fact a machine with starved-weighed feed can produce results which rival or exceed those claimed for costly preplastifying attachments. With starved-weighed feed, you eliminate the conventional proportional feeding device which is standard equipment on most machines in favor of a charge exactly equalling in weight the part you wish to mold. The plunger bottoms every time, and there is no cushion of unused material ahead of the plunger. pieces will not stick in the mold with this method of molding, and part properties such as toughness and dimensions are measurably improved. Strains are reduced to a minimum, and what is most important piece weight is held right on the button. In fact savings in piece weight through production of pieces of uniform weight day in and day out alone justifies the use of starved-weight feed, and bringing the injection plunger clear home.

Now how to weigh the feed and get it to the machine? That is something we have really been studying. Most weighing devices have a margin of error as the device cuts off. They are very expensive. In fact we offer a Toledo device that runs about $3500. Less expensive devices all have some objections, either error, maintenance, cost, difficulty of cleaning, etc. And of course you still have the problem of getting the material up into the feed cylnider of the injection machine after you do weigh out the charge. We have just announced a feeder-loader combination called the Starvway Feeder which operates on a time and time delay principle, and completely eliminates the use of scales except for checking the weight of the shot when the job is first set up. Minor adjustments in the weight of feed going to the machine can be made while the unit is in operation. It is fully automatic, and easily wired into the conventional injection machine circuit. And what is more, the price is in the neighborhood of $1000.00 for the feeder and loader with all automatic controls. The Starvway feeder is a package unit which can be installed on any injection machine, and it is virtually self-cleaning throughout so that color changes are both quick and easy. The hopper of the loader holds enough material for up to 8 hours operation of the average 24 oz. machine. The unit completely replaces the conventional hopper and feed mechanism, and may be located up to 40 feet from the machine it serves.

Preplastifying

The matter of starved-weighed feed is going to rival if not exceed in importance that still controversial issue of preplastifying, as it will produce equal if not superior results on the conventional machine without a major alteration to the equipment. As we heard Gordon Thayer tell about it at the recent SPE Conference in Chicago, one could not help wondering why none had investigated the molding problems caused by the proportional feeding device before. Use of the weighed feed, and elimination of the cushion usually found ahead of the plunger produces startling results. Since the conference I have been in two shops where molders of large parts had figured the same answer out quite independently, and were bottoming the plunger, and weighing the feed by hand. Fortunately our work on the weigher and conveyor has been underway for over a year so you don't have to stand there and weigh the feed out by hand anymore—but that is beside the point. The real issue is—that as injection molders realize the benefits of starved-weighed feed as outlined by Thayer they are going to be forced to reassess the whole delicate matter of preplastifying and decide which method they are going to use to produce identical weight, strain free parts, as both seem to give almost identical results.

107 Members At Philly Meeting

President Mr. William B. Campbell, Project Engineer of U. S. Gasket Company gave expert information on his experiences with Teflon and Kel-f in applications and uses of these Fluorocarbon Polymers.

Mr. Jules Jupa, Plastics Engineer with the M. W. Kellogg Company, spoke on the Properties and manufacture of Kel-f.

Mr. George Neilsen, Plastics Engineer with E. I. DuPont de Nemours and Company, Petrochemicals Division, spoke on the Properties and manufacture of Teflon.

Successful Designing for Plastics Molding

W. M. Halliday

The author stresses the importance of accurately determining the functions and operating requirements. Functionality is often a surprisingly complex matter.

The designer-engineer, when having initially decided that a plastics moulded article is the logical, economical or most suitable choice for any particular application, will still be confronted with a number of vitally important problems. Each of these must be satisfactorily solved before the final features of component design can be settled, and the whole project developed to the manufacturing stages.

The first consideration or problem he will have to deal with relates to the function, or functions, which the proposed moulded article has to fulfil.

Determining the Nature of Functionality

Contrary to what might commonly be expected in actual designing practice, determination of the precise functions to be performed by any projected plastics moulding is usually far from simple or straightforward. A component may be required to perform a difficult function, or a combination of several simpler forms. Rarely does it occur that a moulded article has to fulfill a single, very simple, and easily determinable function. If a successful design is to be evolved, however, it is of primary importance that the nature of the function, or functions, shall be thoroughly understood and completely elucidated before embarking upon the determination of the other design features.

It often happens that a component, especially if it is required for an industrial application, may have a complex functionality. For example, very many components used in connection with electrical apparatus may have to perform a number of separate and distinctive functions. It may be, for instance, that such parts are required not only as insulators against the passage of electrical current or heat, but have also to be employed structurally in order to strengthen a particular portion of the machine in which they are embodied.

In addition to these two important and commonly occurring functions, moulded parts may also be required to enhance the appearance and finish of a complete assemblage. Additionally, or alternatively to these requirements, the designer may desire such parts to be capable of facilitating subsequent assembling, machining or operation requirements.

Even in the case of an apparently very simple form of article required to fulfill mainly a decorative purpose, the determination of precise functions may be more involved than would appear at first sight.

Design for a Fruit Bowl

In the January, 1949, issue of "Plastics," artist-designer G. Fejer described very lucidly and logically the various steps taken in the evolution of an injection-moulded fruit bowl. Readers who carefully studied the points raised in that article will appreciate that the functions to be performed by such a seemingly simple article were, in reality, rather complicated.

Far from being purely a receptacle for containing a specific quantity of fruit, the article had, in fact, to fulfill a number of completely different yet related functions. For example, it had to have a pleasing "feel," and a comparable or even superior appearance to that which would be possessed by a bowl made from glass or porcelain. Secondly, unlike glass or porcelain, the projected article had to be relatively free from the risk of breakage.

Thirdly, the bowl was desired to be free from the risk of setting up condensation of moisture present in the atmosphere of the room. This, indeed, was considered an important point in view of the perishable nature of the fruit.

These three functions, it should be noted, are largely influenced by the type of moulding material eventually selected for the bowl.

The design depicted, moreover, had to be capable of being placed easily on the table and to leave ample space for smaller articles of tableware. To meet this function the designer was led to incorporate a base portion of very much smaller surface area, so that the fruit bowl proper would be raised normally above most of the other articles such as cups, jugs and the like on the table. Lifting the bowl in this manner reduced the surface area of space occupied down to that of a cup and saucer.

The bowl had also to be easily handled, and to meet this function special lipping of the outer rim of the bowl was eventually evolved. Further, to satisfy strength requirements, and to obviate warpage during or after moulding, the bowl was designed with a series of flutes; these also greatly added to the pleasing appearance possessed by the finished bowl.

In all the above connections it will also be observed that the question of functions of the bowl is closely bound up with its shape.

Yet another important function which had to be fulfilled by the fruit bowl in question was the ability to slide it across a highly polished table top without incurring the risk of scratching the surface. The base portion was made a suitable shape to obviate this danger.

Regarding the capacity or size of the bowl, this had to be such as would prevent "burying" the fruit, or obscuring those on the bottom layer. That portion of the bowl carrying the fruit was made very shallow in order to fulfill a dual function. The appearance of the loaded bowl or such shallow form could be more easily promoted due to the user's greater ability to "arrange" the fruit supply to best advantage. Secondly, because of the shallowness of the bowl, the lower layers of fruit would not be damaged or bruised by the weight of the fruit above, since this obviously would not be very great. Shallow proportions of this kind permitted greater accessibility to the fruit supply.

Utilitarian Functions

Apart from need for the bowl to be designed in a manner allowing it to be easily handled, the designer has also to consider questions of packing and transporting the bowls. To facilitate such operations the bowl and base were designed as separate units held together by a simple form of "Speednut." This provision for such a function greatly promoted stacking of both bowls and bases.

Relationship Between Function and Other Design Factors

The functions to be executed by a plastics moulded component exert considerable influence upon the choice of plastics materials; the method of component manufacture; the degree of precision required on essential component dimensions; the accuracy and manufacture of the moulding equipment; the rate of output during production; and the economy of the entire moulding manufacturing project; to mention but a few of the interrelated factors.

It is sometimes averred that functionality is more or less automatically determined, since a designer or prospective user must know in advance exactly what duties the component has to perform.

If these are only imperfectly understood it may well be that the designer will be led to adopt an unsuitable plastics material in the first instance. Alternatively, should he select the most appropriate material, the wrong

moulding or fabricating process may come to be adopted. Furthermore, it might also be that difficult features become incorporated in the component design, which later will give rise to innumerable difficulties when the mould manufacturing or operating stages are reached. Thus, quite apart from the unsuitability of the final product for the purposes and functions envisaged at the outset, the manufacturing cost may prove abortive or excessively higher than first estimated.

Only one such example may be quoted at this juncture, however; this will serve to illustrate the points to be watched when determining the questions of function. The component in mind formed part of a larger assembly of plastics and metallic articles, which was employed in connection with a certain electrical device.

The particular plastics component now being considered had a dual function of acting both as an insulator and a bridge structure on which several other metallic components were assembled.

When initially designed the insulating function **only** was considered and a plastics material capable of giving service in this respect was selected. Upon completion of the articles, however, it was found they possessed structural weakness, with the result that innumerable breakages occurred when the components were placed in service.

To overcome the difficulty, a high-shock resisting grade of material had to be employed which, in turn, involved considerable difficulties and modifications to the moulding procedure. The final outcome was a much higher-priced article, mould modifications and lengthy production delays into the bargain.

All those troubles and added expense could have been avoided had the designer worked out completely the problem of function before establishing finally the component design and commencing the manufacture of the moulding tools.

This is a very elementary example, it is true, yet it does afford interesting guidance upon the nature of the practical considerations to be borne in mind when assessing or determining the functions to be performed by a component.

Practical Considerations Concerning Functionality

It will be helpful to state here some of the chief practical considerations arising when deciding upon the nature or extent of functions to be fulfilled by a plastics moulded component.

The function selected should be as simple as practicable, consistent with the satisfactory working of the component when placed into service. Complicated functions may entail difficulties in two directions. On the one hand, the designer may find it increasingly difficult to select a plastics material and a moulding or fabricating process to give him a finished article capable of performing the numerous or complex functions desired. Sacrifices may have to be made in some connection resulting in a component which is inferior in that particular functional respect.

Complexity of function may easily involve an equally complicated and more expensive moulding tool, or a slower rate of production, which factors, in their turn, will incur additional expense of manufacture.

The functions chosen should also not involve very close dimensional accuracy on portions of the component. Should this occur, the task of making the mould will be rendered more difficult since the degree of error or variation is diminished.

The functions to be performed by a component should also embrace the simplest shape possible in the final component design. If this is accomplished the task of mould design and manufacture will often be correspondingly simplified and expedited, with resultant benefits of lower tool charges and increased rates of production during the moulding stages.

Function should also be as effective as possible. This might appear to be no more than the application of ordinary common sense to the problem, yet it often happens that when a component has been designed, and manufactured, its application into service conditions reveals that a much simpler, or different kind of functioning would have been preferable.

In these respects, as with most other component design features, the designer must bear in mind that a plastics-moulded article is made from a metallic mould which remains fixed in size and form irrespective of the quantity of mouldings made therefrom. Usually, too, such a mould will be hardened throughout or at critical points, and in addition will constitute a piece of precision mechanism which will not lend itself to easy or inexpensive alterations at a later date. Once such a mold has been completed it may prove completely uneconomical or even impossible to modify its shape, in order to obtain a somewhat different moulding, because of the need to alter the functions to be fulfilled by such a component.

It is obviously far better and prudent to have these questions finally and intelligently settled at the outset of the designing procedure.

Functions desired in a particular component must also be of such a character as will permit of ready mold-ability in the material selected. Since the relationship between function, materials, and molding is so vital and intimate, if the designer is not fully conversant with these latter aspects of the moulding technique it will be advisable for him to consult with the plastics molder or mold maker for instruction and expert guidance on these points. In this way he will be better enabled to select those suitable functional features for his component which will be more consonant with efficient mold design and molding production.

Assessing the Service or Operating Conditions

Allied very closely with the functional factor is the question of the accurate determination of the exact service conditions to which the projected plastics-moulded component will be subjected. This too, is a vital consideration which has to be taken into account because an incomplete assessment of such conditions may easily lead to the development of an unsatisfactory design, which may be found to break down in some respect when the part is placed into service.

With a plastics-moulded component the operating or service conditions will generally include some or all of the following points:—

(a) The mechanical or physical loads to be placed on the component. It will have to be determined to what extent such loads take, and also whether they are continuous or intermittent in action. Determination of these points for instance will decide the strength and to some extent the shape of the component.

(b) The electrical insulation capacity to be borne by the moulded article.

(c) The temperature under which the finished component has to operate.

(d) Whether it will be exposed to any chemical action, or atmospheric conditions, and if so the exact nature of same.

(e) Whether the moulded component will be brought into contact with water, moisture, steam, etc., and if so, whether such exposure will be continuous, prolonged, or occasional.

(f) Whether the component will be subjected to rubbing or abrading action.

(g) Whether it will be subjected to strong sunlight, or ultra-violet ray emissions.

Operating conditions will affect in many ways the type of material to be used, the shape and form of the component design and the mould design.

The requirements imposed by specific operating conditions may lead to the selection of certain materials in preference to others which may apparently be available and suitable. For instance, if a plastic molding has to operate at an elevated temperature, obviously a material having a low softening point will be eliminated altogether from consideration. Therefore, plastics materials of the thermoplastic kind might be precluded entirely.

(Continued on Page 22)

The Army's Research and Development Program

Major General Ward M. Maris

Deputy AC of S, G-4, for Research and Development

Contributions by the plastics industries to better living for all Americans and to the defense effort for our common security have been significant and far-reaching. Your work has meant much to the economy of our country and to the happiness and well-being of our people. I assure you that the Army has a full appreciation of all that you have done. We also have great expectations for your contributions in the future, and we know that the record of accomplishment justifies our expectations. You are to be commended on what you have done, and on your plans, and hopes, and aspirations for future accomplishment.

As you well know, there are two basic elements which comprise our war potential. They are first, manpower; and second, the means required for combat. The more critical of these elements is our limited supply of manpower. Our young men make the finest soldiers in the world, in spite of statements made by certain writers to the contrary. But they first need training, discipline, and accommodation to the battlefield. What we really need is more of them.

The only way we can compensate for our manpower deficiency is through provision of such superior weapons, techniques and equipment, that with proper training and leadership our forces can reach a high state of combat effectiveness superior to any potential enemy.

Research

The Army's Research and Development Program is designed to meet this challenge and to insure that we will have not only all the weapons necessary for employment by our troops but that these weapons will incorporate all the latest and best technological features attainable which our economy and natural resources can support. It is obvious to us all that no single weapon can meet all of our requirements. Just as we need balanced forces on land, in the air and on the sea, our respective balanced forces need appropriate systems of weapons designed to meet the requirements of the missions which are the responsibilities of the several elements of these forces.

Our research and development effort, therefore, is based upon the concept of balance, which means that we strive to place in the hands of our troops not just one single fantastic weapon which we all wish through some miracle could prove to be a panacea, but rather all of the weapons and equipment which definitely are needed by the infantry, the artillery and the armored units for combat, and by the various technical services for support—in other words, everything that is essential to victory.

Increasing Costs

On the recommendation of our scientific advisors, the limited funds available to the Army during the succeeding years for research and development were devoted to a balanced plan which included:

First, basic research over a period of years to replenish the reservoir of good ideas which had been largely used up by the war time agencies such as the Office of Scientific Research and Development, from which came the impetus for such things as the atomic weapon, the VT artillery fuze, radar improvements and other similar items;

Second, correction of known deficiencies in existing equipment and improvement of its design;

And finally, development of newer items of warfare, the majority of which are necessarily on a long term basis, because of their complexity and high cost.

You are all very aware of the problems posed by increasing costs. We have these problems of cost in Army research. For instance, in World War II a medium tank cost $81,000—its improved replacement version now costs over $200,000.

World War II field wire, of which literally millions of miles were used and re-used in all theaters, was considered a bit too heavy. It weighed 165 lbs. per mile. The new wire, which has been tested in Korea, weighs only one-fourth that amount and has improved electrical characteristics in addition. Now if someone will only come forth with a practical mechanical splicer that you can carry in your hip pocket, he will be a real hero to thousands of linemen.

The new plastic underwear and insulated rubber boots employing the vapor barrier principle give promise of adding considerable comfort to the soldier operating under both wet-cold and dry-cold conditions. Test teams have gone to Korea to supervise and guide the testing of these items this winter.

Mess kit

To you old soldiers present the news that the old mess kit is on the way out may come as either a shock or a relief. You are undoubtedly aware that plastic trays kept at the kitchen and plastic utensils included in combat rations are coming into use. The mess kit will be one less item to carry and represents another step in the campaign dedicated to reduction of the weight carried by the soldier. Reduction in weight means increase in requirements for lighter materials. Aluminum is already scarce, but its availability is expected to increase. Meanwhile we are amplifying our research on titanium, which is plentiful but expensive to produce. Alloys of this intriguing metal are now available, although not in quantity, which have a yield strength on a comparable weight basis of 1½ times that of large production steel alloys in the fully heat-treated condition. We look forward to the possibility of titanium replacing steel armor plate, thickness for thickness, with a weight saving of 40%. We can foresee titanium as providing weight reduction to artillery in such components as carriages, wheels, platforms, armor shields and possibly the gun tube itself. Substitutions in crew served weapons carried by the infantry should make many thousands of men available to carry rifles. Our engineers would like titanium for military bridges and heavy equipment. In fact, there are so many possible uses for titanium that it bids fair to become the metal with the most romantic possibilities of the future. And, of course, plastics have uses which stir the imagination.

History repeats

That history repeats itself is certainly well illustrated by the fact that the use of body armor as worn by soldiers of the middle ages is again

finding favor currently in the new light weight body armor developed by the Quartermaster Corps and now being tested in Korea. Still newer models recently publicized that will provide defense against a 45 bullet at point blank range bids fair to become one of the most popular items of wearing apparrel in the soldier's wardrobe.

This white, fragile-appearing, rather pretty piece of cloth is made of 2 x 2, basket-weave nylon. Its flexibility is obvious. One would hardly imagine it shielding a soldier from one of the greatest causes of wounds in modern warfare—low-velocity shell fragments. The tensile strength of one filament — 10 to 20 microns, single strand—of this nylon is 150,000 psi, which is about the same as that of alloy steel. Further, the nylon strand has an elongation of approximately 300 percent, compared with only about 25% for alloy steel.

This green panel is proof of the protection afforded by only nine layers of the same nylon cloth when properly bonded. This panel was used in actual test and stopped 50% of a number of metal fragments travelling at a velocity of 1,188 foot seconds. This represents a speed greater than the muzzle velocity of a 45 automatic pistol.

Cloth—covered panel

We make armor of this material flexible by leaving the borders of triangular sections unbonded. This particular section weighs just over a pound per square foot but it will stop half the shell fragments travelling at a velocity of 1350 foot seconds. The unbound material, while in general not as good ballistically as the bonded, is nevertheless effective. An armor vest of this material weighs approximately 7½ lbs. Tests in Korea indicate that our soldiers will wear them willingly. When you realize that the soldier carries a summer load of over 50 pounds into combat with him, you can assess the value that he must place on this piece of equipment, if he is willing to carry this extra weight.

Liner

The helmet liner is made of the same material—laminated and bonded nylon. This one, which was also used in actual tests, stopped 50% of the steel missiles fired into it at a velocity of 1,136 foot seconds, offering better ballistic protection than the World War II helmet and liner together.

Helmet

Used with the new aluminum shell it allows greater protection and comfort and lighter weight. Furthermore, the aluminum shell continues to offer the soldier something which many of you consider to be the old steel helmet's finest attribute — it makes a swell washbowl.

CONNECTICUT QUIZ

By David Mersey

Friday, January 12, found the Connecticut Section gathered at the Barnum in Bridgeport. After the last meeting, someone suggested this as a slogan for the Waterbury members, "neither wind or rain or sleet or night can keep an SPE from a meeting night." Can't find out who it was, so no prize for that one.

We were shown the SPI film, 'Scientific Approach to Plastics.' Much of the film was taken in the labs at MIT at Cambridge, and it presented some excellent shots of the various materials being put through tests.

The serious part of the meeting was another "quiz session." This time the tool makers took a hand at stumping the experts, Rene Magnenet of Waterbury; and Andrew Wargo and Joseph Hodwath of Bridgeport. The winner, for fifteen dollars, was Gunnar Lindquist of Model Tool Co., Bridgeport. Asked he, "In working for various molders, each one has his own ideas on construction, such as types and sizes of runners, pressure pads, etc. Is it possible that each one can be right, as he claims he is?"

Many other questions were submitted. Here are a few. Warren Sharp wanted to know, "In a plunger mold, why use round runners when rectangular ones would make for cheaper construction cost." Andy Wargo came up with, "In a plunger mold, what is the best type of steel for inserts for pin-point gated cavities?" Albert Polci of Waterbury asked, "In a transfer mold, how can you prevent air vents from causing sticking and staining?" C. T. Sloan of Plastic Manufacturers, submitted, "If a tool-maker makes a mold from a product print, should he be responsible for the operation of the mold, dimensionally and otherwise?"

I have here a sample of a disposable plastic syringe. During the last war it became apparent that under many circumstances such drugs as penicillin could not be readily administered far enough forward to enable the wounded soldier to obtain maximum protection against infection. In response to this need there has been developed a disposable plastic syringe of ingenious construction. It consists of a glass tube closed at each end with a rubber stopper, containing the usual dose of the drug. This tube is inclosed in a plastic cylinder fitted with a needle. The needle cover, when removed, is fitted into the other end and forms a plunger which forces the glass tube with its stoppers against the sharp inner end of the needle. The upper stopper then continues down the glass tube forcing the penicillin through the needle. This device will obviate the necessity of sterilizing needles and syringes in front line aid stations, thus making it possible to treat the soldier early and in a simple effective manner.

Blood Plasma

Many of you must have read popular articles on Periston or polyvinyl pyrrolidone which was so extensively used in Europe during the last war as a substitute for plasma. In addition to this substance, a number of other materials are under study. One of these, Dextran, which is produced by a biological process, seems to have considerable promise as a readily manufactured, effective and stable substitute for human plasma. Unfortunately, a number of questions still remain unanswered—among them, the effect of Dextran on the ability of the body to resist infection. It is certain that we must find a cheap, reliable, readily stored and stable substitute for the extremely critical commodity, plasma, in order to save lives during the first few hours after any large-scale atomic attack. This problem is under study in two of the Army Medical Centers, as well as in numerous university laboratories.

Your interest in and support of our research program is appreciated. We hope it continues.

Successful Designing

(Continued from Page 20)

Similarly, if a component has to operate in conjunction with acids, in order to withstand the corrosive effects arising therefrom, it will be essential to select an acid-resistant material.

The designer will also appreciate that when considering working or operating conditions to which a component will be exposed, it will be very advisable for him to assess these at their worst level or maximum effect. This will be essential in order that the eventual design will be enabled to operate effectively and withstand service rigours without the risk of failing, due to a sudden worsening of the service conditions.

Where any special or unusual operating conditions arise, it will be helpful if the designer consults the mold maker and molding engineer to ascertain whether these conditions involve any particular difficulties in respect of the mold, or production from the materials selected.

Where the operating conditions can be maintained as simple, uniform, and as light as possible, the task of the component designer will be appreciably simplified, since he will, in the first place, be afforded greater choice of materials, and secondly, will be able to choose a relatively simple component shape.

(To be continued)

Reprinted by special arrangement with the British magazine "Plastics."

SPE CONFERENCE

(Continued from Page 6)

Companies registered at the Conference were:

American Cyanamid Company, A. Bamberger Corp., American Molding Powder and Chemical Corp., Catalin Corp. of America, Celanese Corp. of America-Plastics Division, The Dow Chemical Co., E. I. duPont deNemours & Co., Inc., Durez Plastics & Chemical, Inc., Fiberite Corp., General Electric Co., Gering Products, Inc., G. F. Goodrich Chemical Co., Hercules Powder Co., The M. W. Kellogg Co., Koppers Co., Inc., Chemical Div., Monsanto Chemical Co., Plastics Div., Naugatuck Chemical Div. of United States Rubber Co., Plaskon Div., Libbey-Owens-Ford Glass Co., Rohm & Haas Co., Tennessee Eastman Co., Detroit Mold Engineering Co., Farrell-Birmingham Co., Inc., The Fellows Gear Shaper Co., Ferro Corp., Improved Paper Machinery Corp., Jackson & Church Co., Lester Engineering Co., National Rubber Machinery Co., American Phenolics Corp., Auburn Button Works, Inc., Autograf Brush & Plastics Co., Inc., The Bolta Co., Chicago Molded Products Corp., Consolidated Molded Products Corp., Doughboy Industries, Inc., Flambeau Plastics Corp., General American Transportation Corp., The General Tire & Rubber Co., Irvington Varnish & Insulator Co., G. B. Lewis Co., John Mack and Son Moulded Products, Inc., Panelyte Division of St. Regis Paper Co., The Plas-Tex Corp., Plastic Research Products, Service Plastics, Inc., Sinko Mfg. & Tool Co., The Sunlite Mfg. Co., Swedish Crucible Steel Co., Plastic Div., Taylor Fibre Co., Waterbury Companies, Inc., Vulcanized Rubber & Plastics Co., Yardley Plastics Co., Midland Die & Engraving Co.

MIAMI

By John L. Russell

Merle Nelson, Supt., of the Plastic Moldings Corp., Cincinnati, O. will lead Miami Valley Section, SPE, as President during 1952. In addition, the Directors voted Charles Selz, Kursch, Inc., Dayton, as Vice-Pres., Ralph Backscheider, Recto Molded Products, Inc., Secretary, and Paul A. MacPhee, National Cash Register Co., Treasurer.

Committees appointed by President Nelson to operate during 1952 are as follows: Program, Martin Kasch in Dayton and Richard Bice, Cincinnati; Credentials, Carl Weber, Crosley Corp., Cincinnati; Kasch is with Kurz-Kasch, Inc., and Bice with Formica Co., Cincinnati; Membership, John Brierley, Bakelite Corp.; Fellowship, Marvin Winemiller, Recto; Technical Activities, Byron Nelson, NCR; Publicity, John L. Russell, NCR; and National Director, Walter Oelman, Standard Molding Corp., Dayton.

Jack Paton of the DuPont Co., Wilmington, Del. Polychemicals Dept. gave a very fine talk on "Molded Nylon—An Engineering Material" with slide illustrations and samples of molded Nylon. Fifty members and 14 guests were present for the very excellent dinner served prior to this at the Crosley Div. Avco Corp. dining room in Cincinnati. The Crosley Div. officials are indeed to be congratulated for their fine generosity in extending to us their facilities for the past two years for meetings. Carl Weber and Carl Ackerman please take a bow!

Miami Valley members who attended the SPE Technical Conference in Chicago were Walter Oelman, who was elected National Vice-Pres., Byron W. Nelson, Gil Carpenter and Carl Ackerman.

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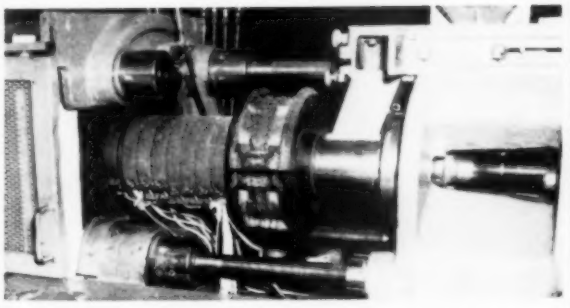

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New Books

"Plastics Molding"

Plastics Molding by John Delmonte is designed to be useful to the plant supervisor as well as to the plastics engineer. A good outline of the coverage is given by the chapter titles, which are: Introduction to Plastics Molding Materials, Hydraulic Pumps for Molding Presses, Mechanical Pressure Systems, Hydraulic Accumulators and Packings, Valves for the Molding Plant, Distribution of Gases and Fluids, Heat for the Molding of Plastics, Material Preparatory Equipment, Design of Compression and Transfer Molds, Injection Molding Machines, Design Features of Injection Molds, Extrusion Equipment for Plastics Materials, Finishing Accessories for the Plastics Molding Plant, Instrumentation for the Molding Plant, and Plant Layout.

As the list of chapters shows, the book is especially valuable to those in the injection and extrusion business. The subjects of equipment, application and instrumentation make the book a versatile text.

Plastics Molding is well-printed and attractively bound; Delmonte is easy to read. The book is published by John Wiley and Sons, 440 Fourth Ave., New York City. 482 pages plus index. Price $9.

VINYL FILM

(Continued from Page 14)

characteristics almost entirely when extruded below at ½ mil in thickness. Table VI shows that the reduction in strength of the vinyl film is not so great that the film is unusable.

TABLE VI
Comparative Physical Test Data on Extruded Thinner Film
Forumla Based on 100 Resin and 30 DOP

	2.0 mil	0.3 mil
Film Thickness		
Tensile, lbs. sq. in	4600	3300
Elongation, %	220	100
100% Modulus	3100	3300
Elmendorf Tear, lbs. in.		
With grain	340	530
Across grain	670	940

In Table VII the cost of three different size extruders is shown, and the cost of the corresponding tubular die film heads. It is possible to make any thickness of film on any of the different size extruders, but naturally, it is easier to make larger diameter tubes with the larger dies.

The physical properties of the film appear to be fully as good as those of film prepared by other methods, and there is a real cost advantage in being able to get into the manufacture of film at a relatively low capital investment. In conclusion, it can be said that many of our customers agree with us that there is a large potential market for extruded film and many of them have installed equipment to manufacture, now that it is known that it can be done.

TABLE VII
Extrusion Equipment Cost

Extruder, 1½" Diameter Screw	$ 4,200
Tubular Die, 4" Diameter	1,060
	$ 5,260
Extruder, 2½" Diameter Screw	$ 8,500
Tubular Die, 8" Diameter	1,475
	$ 9,975
*Extruder, 3½" Diameter Screw	$11,400
Tubular Die, 14" Diameter	3,165
	$14,565

*May also be used with 8" diameter die at $1,525.

Classic Plastics

Sigmund Herbert Halpern, former division product manager of Ideal Toy Corp., has formed his own organization *Classic Plastics, Inc.*, 149 Denton Ave., New Hyde Park, New York, specializing in various types of molding and dipping of plastisol. The telephone number is Garden City 3-1730.

Dunnican Associates

Wm. J. DUNNICAN of DUNNICAN ASSOCIATES, 352 Plymouth Road, Union, New Jersey announces that they have been appointed Sales Representatives by GORDON CHEMICAL COMPANY of Wilmington, Delaware for the sale of GORDON'S "URAMOL" Urea Molding Materials in New Jersey and New England Areas.

DUNNICAN will continue to represent SYNVAR CORPORATION in the sale of their Phenolic Molding Materials and Industrial Synthetic Resins.

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